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COTTON SPINNING AND WEAVING

HERBERT E. WALMSLEY

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COTTON SPINNIN

AND

WEAVING.

A PRACTICAL AND THEORETICAL TREATIS

BY

HERBERT EDWARD WALMSLEY

THIRD EDITION.—Enlarged and Revised.

Manchester:
Abel Heywood & Son, 56 & 58, Oldham Street.
London:
Simpkin, Marshall, Hamilton, Kent, Adams & Co., Limited,
Stationers' Hall Court.
1893.

TS
1575
.W22
1893

C 194473 170

PREFACE TO THE FIRST EDITION.

In compiling this Work the Author's endeavour has been to put before the student in as simple, practical and interesting a form as possible an epitome of the art of Cotton Spinning, coupled with a few hints and remarks which it is hoped may be useful to those aspiring to the important and responsible position of managing the various branches of this great industry.

H. E. W.

March, 1883.

PREFACE TO THE SECOND EDITION.

The present edition has been completely revised and re-written, and with the many important additions forms practically a new book upon both Cotton Spinning and Weaving. The success of "Cotton Spinning" has induced the author to treat the entire subject, from the raw cotton to the woven cloth, as fully and as exhaustively as possible, in fact, to keep pace with these advancing times. The explanations, details and all the calculations for the different machines are given under their respective heads, and chapters have been added upon the Ring Frame, the Electric Stop Motion, etc. With regard to all the most recent improvements in the art of Spinning and Weaving and in the construction of textile machinery, he has spared no pains in endeavouring to keep his book well abreast of the times.

The diagrams will, it is hoped, be found to usefully illustrate the text. Short notices on Management, Cotton, Yarn, Cloth, Workpeople and Production, Wages, Strikes, etc., etc., have been added, and, lastly, on the all-important questions of Technical Education and Foreign Competition. To these the reader's attention is particularly drawn.

The writer's best thanks are due to the eminent firms whose machinery is alluded to for their courteous assistance in the compilation of this work; but more especially is the author indebted to the publisher, Mr. Abel Heywood, Junr., for his extreme pains and kind and invaluable help and advice during the printing and publishing of this volume.

H. E. W.

Serpuchoff, near Moscow,
June, 1885.

PREFACE TO THE THIRD EDITION.

This edition has been entirely revised and re-written, and the author now presents to the reader material that has been gathered during a twenty years' experience in some of the leading cotton mills of England, the United States of America, Russia and India.

The endeavour all through the work has been to treat the subject in quite a new light, and it is hoped that a review of this nature may be of interest to the trade generally. The author is greatly indebted to Mr. B. A. Dobson, of the firm of Messrs. Dobson and Barlow, Limited, Bolton, for his valuable assistance in preparing the chapters devoted to the technical treatment of the subject.

Whether the conclusions arrived at by the author regarding the economic questions touched upon be right or wrong, it is earnestly hoped that the importance of these vital problems will at least arrest attention.

The author is again greatly indebted to the publisher, Mr. Abel Heywood, for his kind assistance and advice in the preparation of this volume.

H. E. W.

Newark, New Jersey, U. S. A.,
October, 1893.

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COTTON SPINNING IN ENGLAND.

There are in England some 45,000,000 spinning spindles, that is, more than one half of all the spindles of the world; nevertheless we have it on the high authority of Mr. Edwin Guthrie, so far back as the year 1883, that "the ratio of increase in the growth of the cotton trade during the last half century has been greatly in favour of continental Europe, the United States, and India, as against the ratio of increase in Great Britain and that the cotton trade does not flourish in Great Britain to the extent that it does in other countries Great Britain is falling behind in the proportion she is doing of the increased trade of the world." That such is the case to-day (it is now some ten years since the above statement was made) is an undoubted fact Statistics of the cotton trade all over the world prove this beyond dispute.

The humid atmosphere and the climate of Lancashire are naturally well adapted for spinning cotton yarns and in this all-important respect Lancashire has a great advantage over most other localities in any part of the world. Another great advantage enjoyed by Lancashire which is of great moment to the spinner and manufacturer, is in the fact of the close proximity of coal, which may almost be said to be in the mill yard. Again, the great clay beds out of which the bricks for building the ills are made, are right at hand, and in this particular es another advantage. Still another and important atter which is of considerable further advantage is he fact that the great engine builders and machine makers are located right in the heart of the cotton spinning districts. Once more, the cotton mills of Lancashire are almost within a stone's-throw of the Liverpool cotton market, and within speaking distance of the Manchester Exchange; thus the manufacturer is able to buy the raw cotton and sell the spun yarn almost at the mill itself.

In the matter of factory labour, Lancashire stands pre-eminent, for nowhere in the world is there to be found such an abundance of well-trained and skilled help. On this head, the following remarks referring to the Oldham Limited Mills, which are taken from an old annual report of the Co-operative Wholesale Society, may not be out of place:—

"The daily discussions which take place amongst the shareholders as to why dividends are small or otherwise, have led almost every intelligent operative to become more economical with materials, more industrious, and to see what effect his individual efforts have upon the cost of the materials produced. In fact the bulk of the working classes of Oldham have mor knowledge of the buying of cotton, working it up, an selling the manufactured goods, than most priva employers had ten years ago. The cotton trade co not now be conducted at all, if mismanaged so was fully as was customary before the spinning compa were established. Profits now are not calculated b penny or twopence per lb. on the yarn, as formerly. Much less than half those rates are welcome, and realise good dividends. The competition between the managers of one company and those of another, and also between the directors of different companies; and the pride which each body of shareholders takes in their own mill, are constantly leading to improvements in machinery and economy in every kind of manufacture, so that it is almost impossible for the management of any mill owned by working men to be seriously defective for any length of time."

The following remarks are by Jno. B. Hawes, Commercial Agent, Richenberg, and are extracted from the *Boston Chamber of Commerce*:—

"The English spinning mill is unequalled in regard to the capacity of its machinery and the economy of its productions. In spite of the apparent perfection of the English machines, efforts are constantly being made to improve them still further, by increasing their capacity and lowering the expense of production. The latter problem is solved by building the machines larger and stronger. The machine which ten years ago had but 100 spindles, has to-day 1,270. The number of revolutions, formerly 8,000 per minute, has been increased to 11,000. The card has been brought to a capacity of 200 lbs., against 80 lbs., and the machine has been so improved that cotton need only be passed once through in order to clean it, instead of twice, as formerly. Ingenious inventions to supply the machines with cotton automatically have been introduced. The English are in all mechanical work ahead of the rest of Europe. They build the most mills, owing to the increase of their industry, and to the fact that old mills are being constantly destroyed by fire. They are also able to change old machines built fifteen years ago for new ones, without financial loss, as the cost of a machine in an English spinning mill is balanced in fourteen years, while in all other parts of Europe it takes from twenty-six to twenty-eight years. England being, therefore; in a position to build more new machines, is far ahead of the rest of Europe as regards machinery, and is able to overcome all opposition.

"Since the passage of the Limited Liability Act about 1870, regulating the lawful requirements of limited companies, great changes with regard to the constitution and management of English spinning mills have taken place. This act removed the personal and joint responsibility of the shareholder, and created a limited responsibility. This caused a large reduction of the private mills, while a large portion of them were changed to limited companies. New mills are nearly all such corporations, because of their enormous size, 60,000 to 140,000 spindles operating in a single mill. To consolidate these companies was easily arranged, as the price of a share was from £1 to £5. Of course these amounts could be doubled or trebled. The shares in this way became very popular, and in Oldham, the classical centre of the spinning industry, for instance, they are held by all classes of people with one remarkable exception. The workmen, who had been depended upon when the low price of the shares was fixed, refused to subscribe, th reason being that they cannot be shareholders in a mil and at the same time make claims for a reduction of working hours and an increase of wages. A workman holding stock would during a strike lose both his wages and the interest on his investment.

"An English spinning association is so constituted financially that one-half, or only two-fifths of the capital is raised on the stock, while the rest is procured on mortgages for short or long periods, with chargeable interest. It is obvious that the shareholder is likely to receive a better interest if one-half or more of the capital is obtainable at 3 or 4 per cent., than if the whole capital were realised by paying 5 per cent. interest. The cost for one spindle in a new mill in Oldham, exclusive of working capital, amounts to 20s., or even less, while in other countries it is double this for steam, and three times as much for water power.

"The continental spinner, in addition to the cost of his English rival, adds the following items: (1) Increased Cost of Land. The English spinner rents a small tract of land for ninety-nine years, and pays a very low price for it. The continental spinner has to buy larger tracts of land, as he needs more buildings, and if water is required, the expense of purchasing water power and building canals is very heavy. (2) Higher Cost of Building. In England are engineers who devote themselves to building spinning mills and who undertake the work *en bloc*. Iron and brick are cheaper, and workmen are engaged by the job. (3.) Cost of Adjoining Buildings. The English mill is limited to the factory. There are no large magazines for yarns, no repairing shops, no residences for managers,

erks, and workmen. Cotton is stored in the neighbour-
ıg railway magazine ; the yarns, partly in the cellar of
he mill, where they are compressed by steam or water,
r sometimes in public storehouses. Repairing is done
in workshops specially built for this purpose. Clerks and workmen must find their own residences. (4.) The continental spinner who buys English machines must add to the cost of the same 10 per cent. *ad valorem*, for freight, insurance duty, and extra expenses, six to nine francs per spindle. The above shows that an English spinner builds a new mill for about one-half what his continental brother has to pay. But the working expenses are cheaper in England than on the Continent, especially if the continental spinner requires coal, as English coal is cheaper than any on the Continent. The English spinner is not at a disadvantage, to say the least, in the matter of wages. This is often not admitted, but let us see. The wages of the English workman are on an average about 50 per cent. more than his continental colleague receives, but he also accomplishes much more. This is due to race differences, and to early education in the business and closer occupation. It is a fact that in an Oldham mill three workmen, and for the last two years two and three-quarter workmen, suffice to attend to 1,000 spindles, while on the Continent five are required. An Oldham mill works three hundred and six days in a year, and on the Continent two hundred and ninety-three is a fair average. The English spinner has no holiday in th
week with the exception of Christmas; he has also a fe
other holidays in a year. A Swiss spinner has, f

instance, fifteen holidays, and in Bohemia quite as many. The latter works one hour less on Saturdays and days preceding holidays, which amounts also to five days annually. The English manufacturers employ no porters; the cotton and coal is brought to the mill and stored. No locksmith, carpenter, or joiner is employed; if they are needed they are procured from the repair shop. He employs only a few foremen. One overseer and two foremen are sufficient for 50,000 spindles; on the Continent one overseer and seven or eight foremen are required for the same service. A comparison between English and Swiss balance sheets shows that the wages paid in England cover the amount paid in Switzerland, provided that both produce the same number of yarn. In both countries 380 francs per spindle is paid.

"The work of an English spinning mill is the simplest that can be imagined. One, for instance, having 60,000 spindles, has at most only two classes, and spins in each class only two numbers of yarn, the whole year through, and always from the same raw material. Little knowledge and supervision is therefore necessary. The sale of the yarn *en bloc* is done by the salesman in Manchester, and one of the directors in Liverpool buys the cotton. The book-keeping is so simple that only very large mills require double entry, the smaller ones using single entry or simple cash accounts. The correspondence is a small one, and yarn and cottons are paid for by check. Purchases and sales are made verbally, and need only a written acknowledgment.

"From the above it is plain that the English spinner has a great advantage over his continental colleague.

I regret that I have not the data to enable me to make a comparison between the English and American industry, or I am sure some of these advantages would disappear. The price of land should be in favour of the American industry. The cost of building cannot be much against us, in spite of higher wages. An American workman can accomplish as much at least, as any workman in the world, and he probably loses less time than the workman in any other country. The American spinner procures his cotton cheaper than his European rival, owing to the proximity of the supply."

These remarks regarding the perfection of English machinery, the capacity of the same, and the introduction of ingenious inventions, etc., are not confined to the English mills; for it must be remembered that most of the cotton-spinning machinery of all other countries is of English make, and is therefore equal in every respect. The advantages referred to above on this head are equally enjoyed by manufacturers all the world over.

In England, where cotton spinning is nowadays understood and carried on with mathematical precision; where everything in connection with the business of building, equipping, and managing cotton mills is reduced to scientific and well-defined principles, it is comparatively easy to assume the reins of management, and to decide upon the policy to be pursued when embarking in the business, either as manager or proprietor. Not so, however, when a man is called upon to assume the responsible and trying position of manager and adviser in a mill abroad. This is where a man is put to the test, where his general all-round practical knowledge, skill, and ability are called into play. None but men of large and varied experience, of determination, self-reliance, and sound judgment should be sent out to fill the leading positions in cotton mills abroad, where so very much depends upon the manager, and where he is daily and even hourly called upon to act on his own individual judgment, and without being surrounded, as at home, with everyone and everything to help and assist him. Nevertheless, the best and most lucrative positions to be had in cotton spinning and manufacturing establishments are certainly to be found abroad, notably in the mills of America, Russia, and India. It therefore behoves a man ambitious to secure such appointment to thoroughly prepare and train himself.

Regarding the cost of a fully equipped mill (non-combed) in England, Nasmith in his work on "Modern Cotton Spinning Machinery" says:

"At the present time mills are built in England to contain as many as 110,000 spindles, and these are filled ready for work at a cost not exceeding 21 shillings per spindle, the apportionment of which is as follows:—The machinery costs nine shillings, the building eight shillings, and the engines, boilers, furnishings, and all accessories, four shillings per spindle. The cost per spindle in other countries is much in excess of the amount stated above, being in many cases doubled. In the United States the cost of a fully equipped spinning mill ranges from forty to forty-two shillings per spindle, and the capital needed for working is also greater than in England. On the Continent of Europe and in India the cost per spindle will be less than in America, but the working expenses are also higher than in Great Britain."

We take exception to Nasmith when he says that the cost of a fully equipped mill in the United States of America is double that of a similar mill in England. The extra cost, according to the writer's experience, does not exceed at the utmost 75 per cent.

Mr. Edward Atkinson, President of the Boston Manufacturers' Mutual Fire Insurance Company, in connection with this subject, says:

"The English fire-proof mill is a very much more costly structure than the American mill, and probably no better, if as good, for the work. The cost of the American slow-burning mill is much less than that of the average fire-proof mills abroad. Iron being very treacherous when exposed to heat, the combustion of the contents of the factories will often tear the fire-proof mill to pieces, although it may not be burned.

THE COST OF MANUFACTURING YARNS.

With cotton at 5d. per lb., the cost of producing standard 32's twist, as spun in Oldham, would be about $7\frac{3}{16}$d. The cost of all wages, including management, is estimated at $\frac{11}{16}$d. per lb. The further sum of $\frac{15}{16}$d. per lb. is put down for the cost of coal, oil, tallow, carriage, etc., including an allowance of $2\frac{1}{2}$ per cent. for depreciation on the building, and $7\frac{1}{2}$ per cent. on the machinery, with a charge of 5 per cent. on one-half the capital (assumed to be borrowed) making $1\frac{5}{8}$d. for labour and capital. If to this we add 5d. per lb. for the raw material, plus 10 per cent. for waste, or say $5\frac{9}{16}$, we get $7\frac{3}{4}$d. as the cost of producing an average quality of 32's twist in a well managed modern mill. This gives a margin of $2\frac{3}{16}$d. per lb., between the prices of the raw material and the value of the yarn when spun. Large mills containing the latest improvements in machinery, and managed with the very strictest regard to economy in every detail, have got down to a margin of $2\frac{1}{8}$d., which is indeed a remarkable achievement in economy.

Again quoting Nasmith on this head, he says as follows :—

"At the time of writing, the price of 32's twist is $8\frac{11}{16}$d., and cotton $6\frac{9}{16}$d. per lb., leaving a margin of $2\frac{1}{8}$d. These figures are based upon the assumption that American cotton of middling quality is used. It is true that a margin of $2\frac{1}{8}$d. is barely sufficient to permit of a profit being made, but $\frac{1}{8}$d. per lb. added will do so, and a margin of $2\frac{1}{2}$d. is considered a large one in these days."

Taking all things into consideration, and not confining ourselves to the cost of producing 32's twist alone, there is quite a variation in the cost of production between one mill and another. Of course, all depends upon the working expenses of concerns, whether they can be worked to advantage or not, that is to say, if the mills are not suitably arranged for the counts it is intended to spin, they cannot in these days of keen competition be worked with profitable results. We know spinners who have actually lost money through spinning too great a variety of counts, when the machinery has not been arranged and adapted for this variation; for instance, when spinning the lower counts, they would overrun the production of the cards, etc., and *vice-versa.* Another important item is the price paid for cotton. Some spinners can buy much more extensively than others, and consequently at a cheaper price. Some spinners would also spin a wider range of counts from the same cotton, whilst others would buy three or four different sorts, according to the numbers to be spun. Again, in thread-yarns some manufacturers will spin a wide range of numbers from the same mixing, and if a certain class of thread requires, say, six doublings, and the margin will not allow it from the kind of cotton that is being used, an equal quality of thread is made with three doublings, compensating for the extra quality or price paid for the cotton. It will thus readily be seen that there are many factors in the element of cost of production.

In England, with the egotism for which Englishmen as a rule are so universally renowned, we are far too apt to ignore foreign competitors, and to altogether overlook the fact that this so-called foreign competition is to a very great extent simply and purely an extension of our keen and fierce home competition, with the important difference that it is carried on under far more favourable conditions. This competition is not merely with Englishmen at home, nor is it merely competition between English and foreign labour and capital, but it is likewise competition between English labour and capital at home, and English labour and capital abroad, for England is constantly and all the time supplying the very best machinery, and the picked managers and overlookers from the mills in Lancashire, to the mills on the Continent of Europe, America, and India, and nowadays also to Japan and China. Surely and steadily has this universal competition been creeping on, and gaining ground, until at last the eyes of at least the more intelligent, thoughtful, and observant portion of the English people have become opened to the fact that a great and powerful competition in the cotton trade is staring them in the face, and has to be reckoned with.

England is no longer alone, and no longer holds undivided sway in all or even any of the markets of the world; on the contrary, she now meets clever rivals on every hand, surrounded with many and great advantages which they wisely make the most of. England's large and ever increasing number of competitors for the trade of the world are now well able to, and do, successfully compete with her upon her own terms, as English merchants and manufacturers know to their cost.

On this head Mr. Edwin Guthrie, in the pamphlet referred to, says:

"The world is to be congratulated on the fact that other countries are also peopled with intelligent and active races, actuated like ourselves, and growingly so, with manufacturing and trading proclivities. They by-and-bye found out that they too could spin cotton, and although for a long while their trade did not prove to prosper by leaps and bounds as did that of Lancashire, the footing they were gaining grew firmer and firmer, until the position acquired by foreign cotton-spinners has struck alarm in the minds of many British spinners and manufacturers of cotton goods." Again: "But besides the circumstance that the people of other countries have found that they too can spin cotton, many modern conditions have contributed and continue to contribute to the encouragement and development of the trade in other countries. The British goodwill in the business is being steadily narrowed by the diffusion of the trade consequent upon its being made easy to all."

Nevertheless we do not wish it to be understood that we take too pessimistic a view regarding the present and future prospects of the cotton trade of Great Britain. The situation, however, in view of the condition and prospects of the industry as carried on in other countries, demands grave consideration at the hands of English spinners and manufacturers.

While fully alive to the fact that England may yet count for years to come upon a large trade in the great markets of the East, in South America, India, and Africa, it is self-evident that England must recognise the powerful and growing competition with which she is met on every hand. The vast magnitude and the tremendous interests involved are of such far-reaching consequences as to be undoubtedly of national and not merely local concern and importance. Let us recapitulate by way of emphasis: the total number of spindles in Great Britain is, say, 45,000,000; the Continent of Europe, 24,000,000; the United States of America, 15,000,000; India, China, Japan, etc., 4,000,000. Thus it will be seen that, roundly speaking, England stands face to face to-day with a total force, in actual number of spindles, on an equal footing with her; and in many respects, as already pointed out, her rivals have superior and telling advantages in producing with her the world's cotton goods.

COTTON SPINNING IN AMERICA.

The cotton spinning and manufacturing industry of the United States of America has, without the least doubt, a future before it, perhaps not even second to the vast cotton trade of Great Britain. The material resources of the United States are apparently illimitable, Nature having endowed the American continent with everything necessary to the comfort, well-being, and advancement of man. The extent and natural wealth of America are such as to create a feeling of wonder and admiration in the mind of the traveller. The American people are indeed to be envied and congratulated in their possession of endless resources, resources unequalled by any other country on the face of the earth. It is almost bewildering to imagine what the condition of things will be only fifty years hence, but it may safely be predicted that the enterprise and energy of the American people, with the great advantages at their command, will cause in the near future a material progress such as has never before been seen in the world's history.

The population of the United States is, at the present time, some 65 million souls, or approximately double that of the United Kingdom of Great Britain and Ireland. This already large population is steadily and rapidly on the increase, and is swelled by the immense number of immigrants who daily arrive from Europe in ship loads. Every immigrant, political economists hold, is worth at least one thousand dollars to the United States. Moreover, not only do these immigrants add to the producing power of the country, but as consumers they widen the market for the varied products of American factories; thus it will readily be seen that the possibilities of the cotton spinning and manufacturing industries of the United States home market alone, irrespective of any foreign or export trade, are practically unlimited. It is, therefore, safe to assume that a judicious investment of capital in cotton mills in America is a safe and wise one, and may be regarded as legitimate and sound commercial business.

There are at the present time some fifteen million spinning spindles in the United States, and there is now what is called in America a "boom" in the fine spinning branch of the industry. Fine spinning is to-day as successfully carried on in America as in England; the production of fine yarns is greatly on the increase, and the quality of the finer spinning of the best American mills is fully equal to the quality of the finer spinning of the leading English mills. In fact, the large thread manufacturers who make very high-grade threads spin all their own yarns for this purpose. Fine yarns are also in great demand for many other purposes, and the importation of fine yarns from England will ere long be a thing of the past, American spinners being alive to the fact that there is a wide field and large profit in the finer branches of the cotton-spinning industry. The manufacture of thread is not confined to any particular locality, but is carried on in different States, notably in New Jersey, Rhode Island, Massachusetts, and Connecticut, while the fine spinning mills generally are centring in and around New Bedford, Mass. Fall River, Mass., is the great centre for spinning yarns 28-32's twist, and 34-36's weft, for print cloths, whilst similar goods are manufactured in mills scattered over the various New England and Eastern States. The Southern States of the Union are likewise asserting themselves, and many mills are springing up in those States for spinning and manufacturing the coarser grades of cotton goods. Hosiery yarns are a separate and distinct branch, and are greatly in demand; the manufacture of this class of yarn is especially successfully carried out in several American mills.

Cotton spinning in the United States is generally understood and carried on as it is practised in England, the American mills being in every essential qualification a counterpart of the mills of this country. The only important respect in which they are dissimilar is that the building of an American mill is non-fireproof, whilst the British mill is built on the fire-proof plan. The greater part of the machinery is of English make, the best makers of Lancashire being about equally represented as at home. There is, however, on the part of the American machinists, a most determined effort now being made to oust their English rivals, and the latter will undoubtedly in the near future have to look t their laurels. Meanwhile they hold the fort. Th engines, boilers, etc., are all, without exception, of American build, and rank with the very best efforts of th leading English makers. All other mill accessories such as belting, banding, bobbins, etc., etc., are of home manufacture. The machinery in the American mills is generally run at a very high rate of speed, and in many instances both the life of the machine and the quality of the work turned out are taxed to the utmost limit, a large product from the machine being looked upon as the all-important factor towards success. The medium-fine and fine mills, however, do not lose sight of the importance of quality first and quantity afterwards, and as a result there is no doubt that these establishments produce yarns of a very superior order.

The nationality of the hands is very largely foreign. The native population finds more congenial occupation in the mechanical trades. Only few Americans seek places in the textile mills, unless it is to occupy positions of immediate or prospective responsibility. Nearly all are of foreign parentage, principally English and Irish, with a considerable number of French Canadians.

In many of the mills there is a great lack of proper supervision, and an utter want of system, order, and particularity, all of which are so absolutely essential where good yarns are the desideratum. The neglect of these important factors will account to a great extent for the inferior quality of yarns produced in these mills. On the other hand, there are very many mills where the direct opposite is to be found, and where the strictest attention to detail, and the most thorough and perfect supervision are the order of the day. Generally speaking, however, in the management of a great number of the spinning and weaving mills of the United States, there is unfortunately a lack of that concentrated and earnest attention and fixity of purpose which are to be found in most of the Lancashire mills, and this is traceable and noticeable all through the various departments. The several heads, from the manager down through the overseers to the "help," do not appear to realise the necessity of attention to detail; there is an indifference to strict duty, and a general looseness and slovenliness that should not exist in a well-regulated establishment.

The hours of labour in the cotton mills of the United States are generally speaking 60 per week; and the self-acting mule spinners, spinning from 32's to 50's, average about 12 dols. per week.

The Clark O.N.T. Thread Company, of Newark, New Jersey, only run their mills 55 hours per week, with the following average wages:

	Dollars.		
Cotton Mixers	9 0 0	per week	
Card Grinders	12 0 0	„	
„ Strippers	11 0 0	„	
Comber Tenters... ...	7 0 0	„	
Frame „	7 0 0 to 8 0 0	„	
S. A. Mule Spinners...	18 0 0	„	Average
Piecers..	6 0 0	„	
Creelers	3 0 0	„	
Winders and Reelers	8 0 0	„	
Foremen	15 0 0 to 35 0 0	„	

" Imports of Egyptian cotton for nine months of the current fiscal year have exceeded by nearly 50 % the imports of that commodity for the same time last year. This cotton all goes to the New England mills, and the movement indicates that there is an increasing tendency to improve the quality of the goods manufactured in that section. Finer yarns are being spun each year, and a better quality of goods is being placed on the market. The large thread manufacturers, hosiery and fine spinners likewise now very largely use Egyptian cotton."

" According to consular advices, the popularity of American prints in the South American markets is increasing under the stimulus of the recently established policy of reciprocity. During the past year the exports of prints and other cotton fabrics of American manufacture to the Southern countries have been larger than ever before, and a steady enlargement of American trade in this direction is confidently to be expected."

" COTTON GOODS FOR CHINA.

" Ten car loads of sheetings and drillings manufactured by the Stark Corporation left Manchester (N.H.), June 11th, 1892, for Vancouver, to be thence shipped to Shanghai, China. This is a portion of an immense order which the Stark mills are filling. It will take 28 car loads in all to ship the 3,000 bales required. It will take four days and nights to complete the packing of the cars, a large force being employed in the work."

The above three paragraphs are taken from the *Textile Mercury*, dated July 2nd, 1892; they speak for themselves. They are actual facts, and are here reproduced as such. They are suggestive of what is being accomplished by the mills of the United States in competition with the mills of Lancashire.

EXTRACTS FROM REPORTS OF THE BOSTON MANUFACTURERS' MUTUAL FIRE INSURANCE COMPANY.

EDWARD ATKINSON, *President.*

Grave faults are apt to be committed in the construction of new buildings by those who do not keep the danger of fire in view from foundation to roof.

SAFE OR SLOW-BURNING CONSTRUCTION.

Solid beams, or beams in two pieces, bolted together; eight or ten feet on centre; not to be painted, varnished, or filled for at least three years after the building is finished, lest dry-rot should ensue. Ends of timbers ventilated by a half-inch space at each side.

Roof timbers laid across the tops of the walls to project 18 to 36 inches, as may be desired, serving as brackets. Plank laid to the end of timbers. No gutters and no boxed cornice of any kind.

Wooden posts of suitable size, not tapered, unless when single posts are turned from single trees following the natural taper. Cores bored 1 to 1½ inches. Half-inch holes crossway near top and base for ventilation.

Floor planks not less than 3 inches thick for 8-foot bays; 3½ to 4 for wider bays. In some cases timbers have been placed 12 feet apart, with 4-inch plank for the floor; but a careful computation should be made of the weight to be placed thereon before so wide a span is adopted, lest there should be deflection.

Top floor, 1¼-inch boards, laid the same way as the plank. The best construction requires the top floor to be laid over ¾-inch mortar, or over two thicknesses of tarred roofing felt.

All rooms in which special dangers exist, such as hot drying, to be protected overhead with plastering on wire lath, following the line of the ceiling and timber, thus avoiding any cavity between the timbers.

In such rooms wooden posts should also be protected with tin, care being taken to leave the half-inch holes at the top and base open, so that dry-rot may not ensue. Iron posts may be protected, first, by a covering of wood and then plastering on wire lath, or by protecting them with the materials furnished by the New York and other Fireproofing Companies.

For the best construction, the roof plank should n
be less than three inches thick, grooved and splic

covered with tin, gravel, or duck, as each owner may choose.

If a pitched or mansard roof is adopted, which we do not advise, the plank should not be less than 2 inches thick, and covered outside with shingles laid over $\frac{3}{4}$-inch mortar—unless the use of slate is considered essential for the sake of appearance. If slates are used, they should also be laid over mortar, as they are subject to almost instant destruction when exposed to a moderate degree of heat, and they oppose little obstruction to the passage of sparks through the cracks. Shingles are also non-conductors, and make a mill attic much more comfortable than when slates are used, especially on a board roof.

In a brick building no granite should be permitted, except for steps or underpinning. Its use for piers and for window-caps is extremely unsafe, as it is subject to very quick destruction by fire. Sandstone window-sills may be permitted, but brick is better and safer than stone of any kind for such uses. Attention may be called to the use of terra-cotta, which, having been baked, is safe from fire.

Each room should be cut off from every other as far as possible. Elevators and stairways inside the main building are to be avoided; they should be placed in porches and fitted with automatic hatches, wooden doors covered with tin, and other customary appliances, to prevent the spread of fire.

Whitewash is safer in respect to fire than paint. An incombustible finish for woodwork is greatly to be desired, all common varnishes being very dangerous.

BASEMENT FLOOR FOR HEAVY MACHINERY.

We have been frequently asked how a foundation or floor should be made upon which to place heavy machinery, in the working of which it is very desirable to avoid vibration.

It has been found that timbers set closely in cement concrete will soon decay, but that in coal-tar concrete they are durable.

The best practice appears to be to place 8-inch timbers, to which to bolt the machinery, upon a solid foundation, and fill in between them with well-rammed stones covered with coal-tar concrete to the level of the top of the timbers. In some cases a board or plank flooring is placed over the whole.

MILL COLUMNS.

Timber-posts offer more resistance to fire than iron pillars, and have generally displaced them in mill work, being preferable in many respects.

Experiments made for this company on the testing machine at the United States Arsenal at Watertown, Mass., show that sound timber-posts of the proportions customarily used in mill work yield by direct crushing and not by crippling; the strength being directly at the area of cross section at the smallest part. The columns yielded at about four thousand five hundred pounds per square inch, confirming the general practice of allowing 600 lbs. per square inch as a safe load.

Square columns are therefore one-fourth stronger than round ones of the same diameter, and do not interfere to any greater extent with the floor space.

It has been the general practice to bore a hole $1\frac{3}{4}$-inch in diameter along the axis of the columns, for the purpose of reducing checking; but the later method is to leave the columns solid. It may be safer to bore the holes for ventilation, lest by inadvertence posts made of unseasoned wood should be painted, varnished, or filled so as to promote fermentation, or what is commonly called dry rot.

There is no part of a mill where good work is more essential than in the columns. It is recommended that the cap, pintle, and base be made of one piece of cast-iron, instead of three, as is the present general practice.

The facts developed by a series of trials of the weight required to crush or cripple wooden columns have led to the following conclusions:—

1. That it is a mistake to turn wooden columns to a taper when worked from square timber, or even turn them at all.

2. That a square column is much stronger, cheaper, and better, provided there is no objection to the form. The objection to the danger of abrading the corners (which may be chamferred off) by contact with trucks, can be avoided by metal guards at the base.

3. That the direct vertical stress to which a column may be subjected without injury is less than has been very commonly assumed; hence the factor of safety in columns in use is less than has been supposed.

4. That accuracy of fitting and placing is an item of great consequence, inasmuch as badly fitted caps and pintles greatly reduce the strength of columns. Whenever and wherever solid beams or heavy timbers are made use of in the construction of a factory or warehouse, they should not be painted, varnished, oiled, filled or encased in impervious concrete, air-proof plastering or metal for at least three years, lest fermentation should destroy them by what is called " dry rot."

It is, on the whole, safer to make floor beams in two parts with a small open space between, so that proper ventilation may be secured even if the outside should be inadvertently painted or filled.

In building a mill the strictest and closest attention should be given to the quality of the material used, so as to ensure a sound and solid structure, fit and well able to withstand the test and wear and tear of time.

It should be seen to it that none but sound bricks and good firm mortar are used. The ironwork and timber should likewise be of the best quality. A solid and firm foundation is also of the first moment. The walls should be strong enough to resist vibration, and should be well set and perfectly true. The rooms should be lofty and the windows large enough to give plenty of light; and, lastly, the floors should be laid and the boards tongued and grooved, so as to get a tight, snug fit from end to end of the mill.

SPRINKLERS.

The standard of adequate protection by means of sprinklers, to which nearly all risks have been brough or to which it is expected to bring all risks, is as follows:—

In textile factories sprinklers are called for over the opening, picking, carding, and spinning departments, over the napping rooms, singeing rooms, drying rooms, carpenters' shops, and all other departments in which there is combustible material, over which a fire would be apt to spread with rapidity.

The Grinnell Sensitive Sprinkler, now offered by the Providence Steam and Gas Pipe Company, of Providence, R. I., is preferred by them to the Parmelee, previously introduced by them, for the following reasons:—

1. Quicker action under heat, for the reason that the fusible solder is entirely separated from the influence of the water in the pipe.

2. Freedom from liability to leak, as the construction is such that the greater the pressure of the water the tighter the valve.

3. A better distribution of water after the sprinkler is in operation, and no possibility of clogging with sediment or lint.

The tests of this sprinkler have given great satisfaction in respect to its certainty and quickness of operation, and it is hoped that it may meet all the theoretical conditions of safety; especially is it hoped that in a card or mule room it may work in advance of the spread of a fire, which its extreme sensitiveness may give us reason to expect when exposed to such an actual trial.

Although it is our custom to avoid creating a preference in respect to one kind of apparatus over another when we accept either, yet, in such an important matter as this, we feel bound to say that we prefer the Grinnell Sprinkler to any other yet offered. At the same time we may mention the fact that other inventors are working in the same direction who may yet compass as good results.

DAMPERS IN DUST-FLUES.

During the past year there have been numerous fires starting in pickers, and thence, by means of a dust flue, reaching the dust-room, and spreading thence to other portions of the picker building through the paths furnished by the dust-flues from other pickers; therefore we wish to call attention to the facility with which such accidents can be prevented, and the fire loss kept within small limits merely by placing dampers at the trunks into the dust-room. In some instances, the damper is a swinging damper, with the pivot slightly above the middle, so that the force of air from the blower of the picker will readily open it; yet it will close of its own weight, and the slight pressure in the dust-room caused by the current of air from the other pickers will keep it close more securely. In other instances, the damper is suspended, pressing against the end of the trunk, and hung at some distance above it, so that the force of the current of air entering the dust-room swings the damper away from the end of the flue, but when the current of air is stopped the damper rests securely against the end.

In one of the fires in a dust-room, which was put out without damage by automatic sprinklers, the dampers were placed in the flues over forty years ago;

and it is not known how many times they have, in this way, performed valuable service by preventing fire from backing up into the picker-room.

COTTON BALES IMPREGNATED WITH COTTON-SEED OIL.

Since the introduction of cotton-seed oil and its transmission in casks and barrels from one part of the country to another, a new danger has arisen to cotton in transportation, as cotton fibres saturated with this oil are very liable to spontaneous combustion. It may be that the more frequent fires in large cotton warehouses of the South and in cotton ships can be accounted for in this way.

Up to this time the Mutual Insurance Companies have been subjected to but one loss in a cotton storehouse, which could be attributed to this cause. This season, however, an instance of saturated cotton has been discovered in one of our principal mills.

Two bales have been received, one of which was saturated to the extent of 256 pounds, the other to the extent of 175 pounds. They were fortunately discovered to be in this condition, and a claim of damages has been made upon the transportation companies. A sample of the cotton has been examined at the Institute of Technology and tested in our spontaneous combustion oven. It ignited at moderate heat in the way in which fibrous substances ignite when saturated with a drying or quickly oxidising oil. The oil pressed out from this small sample has been subjected to qualitative tests, which prove it to be cotton-seed oil.

We therefore warn all our members who represent cotton mills that it would be advisable to have their cotton carefully examined for oil, bale by bale, before putting it into the warehouse.

STORAGE OF OIL.

We urgently advise the storage of every kind of oil in a detached building, in which there shall be the least amount of property of any other kind, and where there shall be the least danger of the barrels or casks of oil being exposed to the heat of a fire.

COTTON SPINNING IN RUSSIA.

Russia, as is well known, is a vast and ever-increasing Empire. Its enormous size and the natural and physical advantages arising therefrom may better be appreciated and understood, when we remember that Siberia alone contains more square miles than the United States of America and Europe put together, with several hundred thousand square miles to spare. The immense and unknown wealth of Russia's natural resources place her in the very foremost rank amongst the great and leading nations of the world.

It is beyond question that Russia is very backward in the development of her natural and unlimited resources. The Russian people, too, are the most backward in point of civilisation of any of the countries of Europe. Notwithstanding this, Russia has within the last twenty-five years, through the force of circumstances and not through any special or extra effort on the part of the Russian people themselves, come so markedly and conspicuously to the fore that it will surely be readily understood and believed that England will require to put forth every effort in order to hold her own in competing with Russia for the trade of Central Asia. What a powerful and well-equipped rival English trade is threatened with in this quarter of the globe ! and what a power England will have to contend with in the near future, in competing for the great Asiatic markets—so vitally necessary for the well-being of the Lancashire cotton factory operatives. When Russia is fairly opened up, and her vast and untold resources are fairly developed; when capital and enterprise have once opened the eyes of the eighty-five millions of Russians to the great and untold natural advantages of their country, who shall say what will be the result upon the commerce of Great Britain ? When this comes about Russia will most assuredly command all the great markets of Central Asia; even now in many of the Central Asian markets, in Persia, Afghanistan, India and China, Russian prints and calicoes are favourably known, and in certain instances have the preference over English goods. The Russian people are at last beginning to realise the wealth and great natural advantages with which they are surrounded, and as a result there are seen on every hand great centres of busy industry, and the greatest commercial activity. Many and great industrial establishments are at work; silk, woollen, cotton-spinning, weaving, dyeing, bleaching, and printing establishments are all in full operation. Most of these busy hives are owned by the Russians themselves, but in many instances they are owned and kept at work by English capital and enterprise.

There is undoubtedly a large, secure, and remunerative field in Russia for the further investment of British capital. In the Empire of Russia, cotton spinning and manufacturing has made great progress during the last twenty-five years, and there is absolutely no doubt that the Russians, besides being in a position to supply all their own immediate wants in the production of cotton fabrics, are destined to control and command the bulk of the Central Asian trade in cotton goods. Mr. Dobson, of Bolton, in a pamphlet entitled " Stray Notes on Cotton Spinning in Russia," very correctly and appropriately sums up the situation as follows : " They [the Russians] have capital in abundance, and the immensity of the population under Russian rule will always give them a market for the whole of their productions, where, as we see, they are constantly adding to the already vast population by their continual annexations. I believe you will admit the correctness of my assumptions. We in England have done our best, by sending out English engines, boilers, and machinery, and further than that, the cream of our practical men to work them, to put the Russians in a position to be quickly and entirely independent of us; and although on equal terms we should have no difficulty in holding our own, handicapped as we are I fear we must dispel any idea of further large business with this country." The writer can vouch for the accuracy of the conclusions arrived at by Mr.

Dobson, having himself been engaged, on and for a period of 11 years in some of the best n in Russia. If any further proof, beyond actual and existing fact of the large number spindles and looms at present at work in Russia, v necessary to prove that the Russians are now i position to accomplish what has just been stated, fact that they are now engaged in the fine branche spinning, as well as in the manufacture of threads sewing purposes, should be sufficient to convince e the most sceptical.

Most of the mills in Russia are built in a substantial manner, and upon the model of the forei factories of England and America, and whilst there some few fireproof buildings, the most generally acce plan is on the American system of semi-fireproof, or so-called slow-burning principle. The machinery is out and arranged to work on the English system, and results attained will generally, in comparison with results attained in Lancashire, make an equally g showing, both as regards quality of work and product With respect to cleanliness, organisation, and discipl the results are, perhaps, superior to, and of a hig order than those found either in England, Amer or in any other country where cotton spinning carried on.

These concerns are altogether managed with strictest regard to economy, and on the principles calculated to lead to success, and it is difficult to where any outside or foreign influence and combinat can encroach upon, or retard the continued developn and success of the Russian cotton spinning industry. On national and patriotic grounds alone, the government and the people will staunchly support and encourage the native manufacture, and the fact that the masses, that is, the peasantry and the workpeople of European and Asiatic Russia, universally clothe themselves in cotton, is a guarantee of a steady and never-failing demand for the products of the spindles and looms of the Russian cotton mills

So far as cotton is concerned, Russia is of course on an equal footing with all other European nations; that is, in buying and securing the raw material, whether Egyptian, American, or Indian, she has equal access to the markets, and is in no sense handicapped in the race. The cottons used in the Russian mills are Egyptian, Brazilian, American, Surat, and likewise a cotton that is now very successfully and extensively grown in Southern and Central Asiatic Russia; the latter being principally used for numbers up to 24's, and in certain proportions, when mixed with Savannah cotton, for coarse weft, or filling yarns, up to numbers 36-40's. The writer has seen and used cotton grown in Russia from American seed fully equal to the average quality of ordinary stapled American cottons. The staple spinning of the Russian spindles are 32-34's twist yarns from Egyptian and American cottons, and 36-40's weft from Savannah. The wastes made are used up again, being mixed with a certain proportion of low quality cotton, and then spun in coarse low grade yarns. The lowest wastes are made into wadding, a separate and distinct business, very successfully and extensively carried on in Russia. This wadding, for which tl is a great demand, is used for lining the heavy overc worn by the Russians during the cold winters of country. The staple trade in cloth is what is know Mexican T cloths, and China or light shirtings. finer yarns are woven into fabrics of finer texture; in the manufacture of sewing thread, yarns of var numbers and qualities are in demand. In the dye printing, and weaving establishments the designs of a very high order, and the superior quality prints and calicoes turned out is very noticeable. Dy and printing have arrived at a high state of perfec in Russia. In the element of labour the Russian n are, so far as trained help goes, in quite as goo position to-day as any other Continental people wl cotton spinning is carried on. The stupid and egotis notions of skilled superiority entertained by the co factory operatives of Lancashire are nothing but r nonsense and ignorance. What does such supp superiority amount to? What is the real market v of this so-called extra skill? Absolutely nothing. is on the face of it ridiculous. Cotton-spinning machi of the present day is so automatic in its action, an wonderfully perfect and accurate in construction working, that comparatively speaking no special ski nowadays required on the part of the operatives, certainly far less attention than was formerly case is necessary. In other words, the macl supplies the skill and intelligence of which it has relie the workman, and the latter has under the chan condition of things simply become a mere ordi machine himself. Regarding the aptitude and efficiency of the hands (Russian mill), quoting again from the pamphlet already referred to, Mr. Dobson says: "I have seen boys of 12 or 13, both in the daytime and in the middle of the night, weighing the cotton coming from the opener, to spread on the creeper of a scutcher, and noticed that they performed this work with as much celerity and exactness as could be expected from any person, juvenile or adult. I have noticed the strippers and grinders and the card-room hands performing their different operations, and can guarantee that they take no longer time to do this work than English workmen would require to do it. I have seen the frame-tenters doffing, and have seen them doff the bobbins and replace the flyers and re-start the frame, as it seemed to me, as quickly as our workpeople in England do it. I have seen the piecers on the mules and ring-throstles, when an end was broken, piece that end as quickly and adroitly as anyone possibly could."

This testimony, coming from such a keen and careful observer of everything pertaining to the inside working of a cotton mill as Mr. Dobson, should be sufficient to convince the reader of its accuracy; the writer can vouch for it, were that necessary. When we remember, too, that side by side, so to speak, with their English and American fellow-workers, the Hindoos in the mills of Bombay, and the negroes in the mills of the Southern States of the American Union, handle the work and the machinery of a cotton-spinning mill with comparatively equal ease and expertness, it must be conceded that the so-called skill of the cotton factory operative is nowadays reduced to a very small amount, and cannot any longer be considered as the birthright of Englishmen alone. It is difficult for the Lancashire cotton mill hands, even to-day, to bring themselves to a right understanding regarding this self-evident fact; they do not wish to recognise or admit the changed condition of things, and they even go so far as to deny that the work of a cotton mill has become familiar and is made easy to all, no matter what his colour or nationality. Nevertheless, such is the case. The conclusion arrived at by the writer on this question, after actual experience in England, America, Russia, and India, is that the native workpeople in each of the above-named countries can, and do, under the different local conditions existing there, such as climate and hours of work, attain the best results possible, and that they fulfil all the requirements demanded by the trade and meet all necessities in each individual case and country. The success and ease with which cotton spinning is now carried on all over the world, in such different climates, with such widely different characteristics, and under such varying conditions of labour, should be convincing enough that the industry of cotton spinning to-day belongs to no particular nationality, but is equally the property of all, and is equally as well understood by one nationality as by the other. This is the plain unvarnished truth of the matter.

Until recently, the Russian mills worked night and day, or 144 hours per week continuously; this was of course accomplished by two sets of hands changing or shifting every six hours. Night work, however, has lately been abolished, and the mills now work 90 hours per week, iz., from 5 a.m. to 8 p.m. On five working days out f six, the engine runs from 5 a.m. to 8 p.m., with a toppage of half-an-hour for breakfast, and one hour for dinner; on Saturday, the engine runs from 5 a.m. to 6 p. m., thus the actual running time of the engine and machinery per week is 79 hours. The hands are kept in the mill an hour after 6 p.m. on Saturday, to clean the machinery, and have everything ready for starting again at 5 a.m. on the following Monday without loss of time. Many of the mills work 18 hours a day, or 104 per week without intermission; this is accomplished with two sets of hands. As a set off, however, against these long hours, there are in Russia a great number of native and religious holidays in the year, reducing the average number of working days per month to about twenty-two and a half; still, after making this allowance, it will be seen that in comparison with the number of hours worked per year in the English and American mills, the Russian mills are kept at work several thousand hours per year more than the former. The wages paid, in comparison with the wages paid in England, are very low, a spinner's monthly earnings amounting to from 25 to 30 roubles per month; the earnings of the rest of the hands are in proportion. This, however, is considered a fair remuneration, as the cost of living in Russia is considerably lower than in England. In the element of wages and living, it is important to point out that the higher or lower plane—as the case may be—on which the workpeople of different countries live must not b overlooked. For instance, the working class as a whol in America live on altogether a higher plane than their fellow-workers of England; this applies again with equal force with respect to the English working-man as compared with his Russian brother. When speaking of the cost of living, and making a comparison thereon, one country with another, this must be borne in mind, as it is not so much what it actually costs to live or exist upon, which in any country can be accomplished for a very small outlay.

The Russian workman, as a rule, is a very handy, quiet and inoffensive person, and can be handled and managed without much trouble or difficulty. Unfortunately, the good-natured, kindly disposition of the Russian people, and their bearing uncomplainingly the many hardships they are called upon to endure, have resulted in much harsh and cruel treatment at the hands of their foreign overseers and managers. If trodden upon, the worm will turn; and even the long-suffering and patient Russian workman will at last rebel and attempt to throw off the yoke. There is, however, seldom any excuse to be made for those in power when a strike occurs, for it must be said in favour of the Russian mill hands, and in common fairness to them, that such a proceeding would not be resorted to on their part were anything approaching fair treatment accorded them. In handling the different people of and in different countries, the mistake usually made by English managers and overseers is, that they endeavour to manage them from a purely English standpoint, and on the same lines as they were accustomed to manage the hands in the mills at home; this of course is wrong, and leads to trouble and unpleasantness. Whilst endeavouring to manage the hands so as to get out of them the best possible results, due regard and consideration should always be had to the conditions of the country and the characteristics of the people of that country. To-day we believe there is a better understanding generally between employer and employed in Russia than was the case a short time ago. The authorities, whilst upholding and encouraging the employer by every legitimate means, at the same time insist upon better treatment for the employed. It may be taken for granted that when any serious labour trouble does occur in any of the Russian cotton mills, there is something radically wrong somewhere, and that something may and will generally be found in the misdirection of the so-called management.

The low wages and long hours prevailing in Russia enable the manufacturer of cotton goods to turn out yarns and calicoes at as low a cost as the same articles can be produced at in any other country. A fully equipped spinning mill will cost in Russia some 75 per cent. more per spindle than a similar mill in Lancashire; that is, taking the cost in Lancashire at, say, 21s. per spindle, the cost in Russia would be some 35s. per spindle. In this section it would at first sight appear that the Russian spinner is under a great disadvantage as compared with the English spinner This apparent disadvantage, however, is counterbalanced by, first, the greater number of hours worked per year in the Russian mills; and second, the low wages paid, thus proportionately and considerably reducing the cost per lb. of spinning on account of th extra production and low wages. In the element of fuel the Russians have coal in more than abundance, although the mining of coal in Russia is only yet in its infancy, many of the vast coal fields not yet having been tapped or touched. Many of the manufacturers are using Russian mined coal at less cost than they can get it from England. Others, again, use wood; others naphtha, and some turf. At the present time, however, fuel is an expensive item, and one of great importance in Russia; and must remain so until the coal fields are more fully developed, and the means of transit improved; in fact, coal in abundance must be delivered at the mill at considerably less cost than at present, before the cost of power can be compared with the low cost of power in England. This subject of fuel is a very leading one, and of great importance in Russia, wood being the fuel most generally used in the outlying districts. St. Petersburg, the capital of Russia, and Lodz in Russian Poland (the latter is called the Russian Manchester) have a considerable number of mills, representing quite a large proportion of the total number of spindles in Russia. Coal is obtained easily and cheap in these two places, and is chiefly used for fuel.

Where wood is the fuel used, the manufacturers invariably own large forests, the timber of which is cut down in the summer and transported to the mill yards in the winter on sleighs. A sufficient quantity is cut and brought to the mills to last a whole year, advantage being taken in the winter of the frozen snow for transporting the wood from the forests to the mills, etc. At the mills where naphtha or petroleum is used—and there are many such in Russia—a considerable saving in cost over either coal or wood is claimed. In this section Russia is well able to compete with America, as they have an apparently inexhaustible supply of oil in the neighbourhood of the Caspian Sea; literally speaking, there are rivers of oil. With regard to the item of fuel, therefore, whether coal, wood, or oil, the outlook for generations to come is of the most promising nature, and will turn into distinct advantage whatever disadvantages Russia may now be under through the present extra cost in the expensive item of power.

On the question of cost of reaching the consumer, Russia, of course, in providing for her own people, has complete command of the situation, the mills being on the spot to produce cotton goods with which to clothe her 85,000,000 people. With regard to reaching the consumer in Central Asia, Russia fears no competitor, as she has already annexed most of that part of the Asiatic continent, and will take good care no other nation interferes with her trade in that part of her possessions. Again, the merchants of Central Asia and the surrounding countries visit annually the great and world-renowned fair held at Nishni Novgorod, and there make their yearly purchases on the spot from the Russian merchants, after examination of the goods on sale, which are manufactured in the Russian mills Once again quoting from Mr. Dobson's pamphlet "The cloth produced is generally sold at the Nishn annual fair to the merchants from the interior of Asia

The ramifications of Russian trade can only be comprehended thoroughly after a visit to this celebrated fair. Thousands of individuals of every Eastern nationality, and in every description of costume, picturesque or dirty, come to this wonderful fair, which, according to the amount of money turned over during the weeks of its existence, practically determines the condition of the Russian cotton spinning and weaving industry for the next year." The mere fact of this great and wonderful fair being held on Russian soil regularly every year, and drawing together as it does all these different Asiatic people, is in itself a bond of union and strength between the merchants of these countries and of Russia, and is likewise a guarantee of Russian supremacy over the Asiatic trade. Actual and direct contact of this nature gives an impregnable position to the Russians which will withstand any outside assault upon this vast trade. There are, besides that of Nishni Novgorod, other important fairs held in Asiatic Russia, which further strengthen Russia's hold on the Asiatic markets.

As a sign of the times, Russia may also be mentioned as a country where technical education receives considerable attention, the subject being recognised there as one of the institutions of the country. In St. Petersburg, in Moscow, and in other towns, technical institutions have for some time past been in full working order, with a regular staff of teachers and all necessary appliances. These schools are well and influentially supported, and are making their influence felt in all directions. Thus, the Russian student and artisan, besides enjoying the benefit of learning his trade under the most skilful English overlooker, has the further advantage of high-class, well-organised, and thoroughly established technical schools where he is taught how to work with both head and hands. An eminent French official has declared that he was not disturbed by the cost of the Art Schools of France, for, said he, "it is not France, but America and England which pay for them, by buying the beautiful manufactures and designs which the Schools have enabled the French people to produce." Russia, it may be added, evidently fully appreciates the force of such remarks.

To sum up, who can foretell what the future of Russia may be when her immense resources are fairly developed? Favoured with abundant and cheap labour with long working hours, and given the fair start which she now has, Russia alone, without any outside aid whatever, will in the course of a very short time be a most formidable rival to England in all the great markets of the East. Russia's financial difficulties are well known, but in instancing her as a powerful rival in the further extension of the cotton trade of Great Britain, we do so bearing in mind the troubles she has before her and with which she is surrounded; but at the same time, well remembering what her capabilities are.

COTTON SPINNING IN INDIA.

Mr. Thomas Ellison, the eminent Liverpool cotton broker, in his valuable work on the cotton trade c Great Britain (1886) has not hesitated to place it c record that England's most formidable rival and con petitor in the cotton trade is India, and that most unquestionably Manchester has more to fear from rivals in India than from either American or Continental competitors. Again, a recent article in the *Bombay Gazette*, entitled "The Conflict between Eastern and Western Civilisations" credits Dr. Gustave le Bon with the statement that the low wages prevailing in the East must enable Asiatic manufacturers to undersell their European competitors. There can be no doubt that the progress of cotton spinning in India is a matter of capital import to Lancashire, and therefore it may be well to examine the conditions which surround the present position and the future prospects of this great staple industry as at present understood in our great Eastern dependency.

The daily reports published in the Bombay papers show that the cotton spinning industry of India is at the present time in a remunerative condition, and this, it should be borne in mind, in the face of very lax and careless management, even at many of the mills showing good dividends. This being so—and it will be endeavoured to prove the truth of the assertion later on—it is self-evident that, with enterprise and energy on the part of the millowners, rigid and strict economy, coupled with vigilant supervision in the management of the mills, less carelessness on the part of the workpeople, and friendly common interest among all concerned, there is undoubtedly a good future in store for the Indian cotton industry. Comparatively speaking, cotton spinning in India is yet only in its infancy, and is capable of almost indefinite expansion. That it is bound in the near future to make rapid strides, and develop to a magnitude second only to the vast cotton trade of Great Britain, is the writer's firm conviction after close and careful inquiry on the spot.

In the natural order of things, and taking all the surrounding circumstances of the case into consideration, there must of necessity be a wide and rich field for capital and enterprise in the direction indicated. No possible combinations can confine the cotton trade of India within its present narrow limits; on the other hand, there is every indication of a new departure into the medium and finer branches of cotton spinning. Already No. 30's are being spun at many of the mills in Bombay, with every prospect of successful competition with Lancashire spinning. In considering this all-important question, we will examine the relative positions of India and England with respect to (1) cost of raw material; (2) cost of mills and machinery; (3) cost of power; (4) cost of labour; (5) cost of reaching the consumer. Mr. Guthrie, in his paper read before the British Association Meeting at Southport in 1883, said that the cost incident to the spinning of cotton might be roughly divided into the above five elements. In the first-named element—cost of raw material—India should be credited with a distinct advantage over England in competing for the trade of the East. The cotton is on the spot—practically at the mill doors. That the raw material necessary for the medium and finer spinnings can, with careful cultivation and scientific irrigation, be produced in India, is an accomplished fact, as proved by Messrs. Sugden and Co., of Kaira; and that it can be grown in sufficient quantities, with energy and enterprise rightly directed, there can be no doubt. Samples of cotton grown on the above-named farm were some few months ago submitted to several English mill managers in Bombay, and the report drawn up by them was to the effect that after careful examination of a fair average sample of cotton submitted, they were unanimously of opinion that a first-class quality of 50's twist could safely be spun out of it. The Bombay Chamber of Commerce and the Bombay Millowners' Association likewise reported most favourably on the cotton, describing it as remarkably clean, and of a beautiful colour, with a long, strong, fine and silky fibre. The writer himself was one of the managers referred to above, and may perhaps add that the cotton was grown from Egyptian seed.

The *Advocate of India*, a Bombay daily paper, in a leader on this subject, is most sanguine, and congratulates in the heartiest manner the Indian cotton spinner, expressing itself full of hope as to the future of this new and important industry. Much of India's future prosperity depends upon the cultivation of good cotton, and there are evident signs that the Indians recognise the necessity of fostering and encouraging this great source of wealth to their country, and that they will not allow this valuable industry to slacken or be lost for want of a little energy. It is proposed that there should be a scientific classification and cultivation of all cotton grown, with judicious selection of cotton seeds; also that prizes should annually be awarded to the first-class cotton growers; that the industry should be encouraged and made to flourish by all means in the power of the Government, and that improved implements of husbandry be introduced and brought into use. Altogether there is now much encouragement to produce really good cotton in India, and if a few more railways are opened, it will be a distinct gain, as with an increased number of railways, the people will become richer through being able to sell the produce of their lands; and as a matter of course, by becoming richer they can devise means for irrigating their lands and will be enabled to grow cotton similar to American. Thus a still greater competition with Lancashire will grow up proportionately to the amount of cotton of this quality produced, and the same kind of goods will be made in India at less cost than they can be produced in Lancashire. As proof of this it is only necessary to point to the great trade in coarse numbers (16's to 24's) that has steadily grown up in Bombay during the last few years, and to the large and increasing exports of these Indian yarns to China and Japan, virtually to the exclusion of English yarns of these numbers in the great markets of the East.

Following up our inquiry as to the relative positions of India and England in the matter of cost incident to the spinning of cotton, we come to the second element referred to, viz., cost of mills and machinery; and in this section it would at first sight appear that India is under a distinct disadvantage as compared with England. The English mule-spinning mills in working condition represent on an average a value of about

20s. per spindle, whereas the mule-spinning mills India represent a value of, say, 40s. per spindle. T advantage, however, in favour of England is m apparent than real, being fully counterbalanced by number of working hours in India being so mu greater than in England, thus considerably reducing charge on every pound weight of yarn spun, represen under the head of rent, depreciation and inter The hours worked in the Bombay cotton mills a averaging the whole year round, about 80 per week, against some 56 working hours in England. Thus machinery in India is running some 24 hours per we longer than the machinery in England, or in ot words the cotton mills in this country are standing i for this long time every week, during the whole which the mills in India are busily at work. Eig hours per week, multiplied by 50 weeks in the ye gives 4,000 working hours per year to the credit India. Fifty-six hours per week multiplied by weeks in the year gives 2,800 working hours per y to the credit of England. This, of course, represent dead loss to England, as compared with India, of so 1,200 hours per year, on the enormous amount capital sunk in the cotton spinning mills of t country, whereas on the other hand, the machinery India is working away and turning over the su capital it represents some five months of Engl working time every year, during which the machine in England is at a complete standstill.

As we shall have occasion to refer to this mat again, we will now turn our attention to the th element in our inquiry, which is cost of labour, and here India enjoys a great advantage over England, for the advantage which England possessed in regard to skilled labour most certainly does not now apply as in former years. It must be admitted on all hands, as we have before pointed out, that with the marvellously perfect and self-acting machinery of to-day no special skill is required on the part of the attendant. The machinery itself supplies the intelligence; all that is required from the workman is attention in "following up" the machinery, such as piecing broken ends, doffing, and other simple details, which are performed by the native Indian cotton factory operative almost as well as by his European brethren, and at far less cost to the spinner. Again, as the Indian workpeople become less careless and more attentive, each individual workman will, as a result of his greater efficiency, produce still more and better work, at, of course, still less cost to the spinner. As wages constitute a good half of the cost of production in the spinning of cotton in England, the cost of labour is a very heavy and important item. In India the actual cost in wages per lb. of yarn spun, is about half that of England. It is undeniable that, with the wonderful automatic cotton spinning machinery of to-day, the true value of factory labour is considerably less than it formerly was, when skilled labour was in demand; and I maintain that this fact ought, in the interests of the cotton trade of Great Britain, to be made *prima facie* a subject of earnest consideration and inquiry. Competition would certainly be easier if wage were lower. A reduction in their, rate often make all the difference between profit and loss. An obstinate refusal to accept lower wages prevents the trade from being carried on profitably, in competition with foreign countries where wages are so much lower, and hours of work so much longer; continued, it will prevent trade from being carried on at all. A moderate gain for the masters as well as for the men, and a successful competition, make the best and real co-operation. It is therefore for the co-partnership of capital and labour to determine to what extent the cost of labour is responsible for the loss of supremacy with which our trade is menaced in India and in the open markets of the East.

We now come to the cost of power. Under this heading—again quoting from Mr. Guthrie's paper—India is at present working under a disadvantage as compared with Lancashire, as coal is nowhere cheape than here; still, by the great economy of fuel now possible in consequence of the improvements in engines boilers and machinery, the relative importance of this element of cost is smaller than was formerly the case and it must become smaller still. We have also to look to the development of the Indian coal fields, which sooner or later must yield a large and increasing output at a diminished cost. Again, there is petroleum, which, in the opinion of many, is probably destined to become the universal fuel of the not very far distant future. Note its rapidly extended and increasing use in Russia; the use of it in the Indian mills and factories would at once reverse the present order of things, and turn the disadvantages of the present extra cost in the expensive item of power into an advantage. For the moment, however, the high price of coal in India is a rather serious item in the cost of production, and England must be credited with a decided advantage on this head.

In the fifth element—cost of reaching the consumer—the substantial advantage enjoyed by India over England is very apparent and real, India being in the very centre of the great Asiatic consuming markets, which are the largest in the world. Thus, after careful analysis of the "pros" and "cons" of the whole case, it would certainly appear that India is destined in the near future to compete with England in the medium and fine branches of cotton spinning, as she has already so successfully done in the coarse branch, and it is surely no exaggeration to say, with every prospect of equal success.

In the management and general conduct of the business of a large number of cotton-spinning mills in India, there is very great room for improvement. At too many of these mills the machinery is allowed to run to wrack and ruin; economy is unknown, and there is an utter absence of discipline and order; the workpeople are in a complete state of demoralisation; and the mismanagement is most glaring, amounting to wilful and culpable neglect. The unsatisfactory state of affairs at these mills may be traced to two causes—first, to having non-practical men as managers, and second, to the bad and vicious system of payin the agent commission on the out-turn irrespective profit or loss. These concerns would yield far bett returns if well managed, and if the agent were pa on the sound principle of so much per cent. commission on the nett profits, after allowing for depreciation and renewal funds; or still better, if there were a salaried agent or manager under the control of a strong board of directors, as at the mills in Oldham. Practically, the agent of a mill in Bombay is himself master, manager, and board of directors all in one, with unlimited power, and virtually responsible to no one; the directors know little, and the great bulk of the shareholders absolutely nothing about the business. The agent, either a Parsee or a Hindoo, is not a practical spinner, and in many instances he does not even understand the theory of cotton spinning; yet besides virtually managing the mill, he conducts the commercial and financial part of the business at his offices in town, and both buys the cotton and sells the yarn. It must be said, however, that in the purely commercial or trading branch of the business he is undoubtedly clever. If the agent is a Hindoo, he invariably employs as his right-hand man at the mill a Parsee, who is nominally the manager, with one or two English masters under him to attend to the practical working of the different departments; but if the agent be a Parsee, he employs one of his own caste—a Parsee, as manager, and with him he works hand-in-glove. In these cases the overlookers and jobbers are also Parsees. With one or two exceptions, these Parsee managers are not practical men; they know little more than the *a*, *b*, *c* of the theory of cotton spinning. The Parsees as a people are, as is well-known, far cleverer, and have far more brain power than the Hindoos, and many of the shrewder and more enlightened of the Parsee agents, although they have one of their own caste as nominal manager at the mill, leave the practical management and working of the different departments in the hands of English masters, and, as a matter of course, with most satisfactory results. Where, however, this distinction is not made, and where there are such antagonistic interests and such diversity of race and opinion as when English, Parsees, and Hindoos are all working together, or rather, it should be said, working against each other, with no interest in common or mutual good feeling, the result, as a natural consequence, is much mismanagement, with serious loss and annoyance to all concerned.

Those Bombay mills which are entirely under English control and management, are, it goes without saying, the most successful, their results being eminently satisfactory, but it is only too self-evident that the reins of management at some of the mills are in the hands of thoroughly incapable men, who are likewise utterly indifferent to the true interests of the shareholders, as the following comparisons will show.—No. 1 mill is one of the best managed mills in Bombay, and produced during twelve months from a given weight of cotton a certain weight of yarn, which left a loss in waste between the raw cotton and the spun yarn of 19 per cent. No. 2 mill, working similar counts, consumed the same weight of cotton, but produced 12 per cent. less yarn, or 31 per cent. loss in waste between the cotton and yarn as against 19 per cent. loss in No. 1 mill. At No. 1 mill the machinery is kept in first-class working condition, and turns off in twelve working hours 5¾ ounces per mule spindle of 20's yarn, good quality. At No. 2 mill the machinery is completely run down, and turns off in twelve working hours 3½ ounces per mule spindle of 20's yarn, very poor in quality. All this waste of money, depreciation in the quality of the yarn, low production, extra percentage of waste made, and ruin of machinery, is brought about through neglect, bad management and incapacity. The writer himself can vouch for the accuracy of the above, and he has seen self-acting mules from one of the best makers in Lancashire, broken up and sold at the price of old iron, when with anything like reasonable care they should and would have worked well for another ten years. To a practical mind the above facts speak for themselves, and it is not to be wondered at that there is a feeling of distrust and dissatisfaction in the minds of many of the mill shareholders of India.

The Bombay spinning mills are in no important respect dissimilar from the Lancashire factories, and the machinery, all of Lancashire make, is of the very best, with all latest improvements. That the Bombay mills are well abreast of the times in this respect, the following few particulars of a modern Indian spinning mill will show.—Horizontal compound condensing steam engines, with a boiler pressure of 110 lbs. per square inch, and a piston speed of 600 feet and 60 revolutions per minute; fly wheel 28 feet diameter, with 1¾ inch cotton ropes; polished Whitworth's patent compressed fluid steel hollow crank-shaft, the steam valves of the cylinders fitted with latest improved patent Corliss valve gearing with Corliss exhaust valves; high speed governor and gear on Porter's principle, with Knowles's patent supplementary governor connected, etc. ; improved two-flued boilers, thirty feet long by seven feet diameter, with two flues through, each flue crossed by five circulating tubes (the boilers throughout are made of the best annealed steel plates, etc.) ; Green's fuel economiser : taking a fair average of the Bombay cotton mills, the consumption of coal is about 2½ lbs. per indicated horse-power per hour; some mills, of course, work more economically, some less. Machinery: improved cotton bale-breaker and exhaust-opener; scutchers to make laps 40 inches wide, revolutions of beater 1,500 per minute; revolving flat carding engine with 50-inch main cylinder, running 160 revolutions per minute; hardened and tempered steel card-clothing (carding engines on this principle are now being generally adopted in place of the roller and clearer engine at the modern cotton mills in Bombay, the great improvements that have been effected in the revolving flat card, the superior carding, and the additional weight produced on this system being fully recognised by the Indian spinners); drawing frames, with case-hardened bottom fluted rollers, speed of front roller 350 revolutions per minute; slubbing frames, 72 spindles each, speed of spindles 500 per minute; intermediate frames, 112 spindles each, speed of spindles 650 per minute; roving frames, 144 spindles each, speed of spindles 1,050 per minute (the above frames are adapted for working either Surat or American cotton with a view to the medium branch of spinning); self-acting mules containing 1,500 twist spindles per pair, speed of spindles 9,000 revolutions per minute, with the carriage making four draws of 66 inches in 54 seconds, spinning 20's twist out of Surat cotton. These mules have all modern improvements attached, and are adapted for spinning 32's twist out of American cotton. In the best managed mills in Bombay the modern self-acting mule by the best makers is turning off in twelve working hours full six ounces per spindle of 20's twist out of Surat cotton; or in other words, 50 hanks per spindle per week of 80 hours. The preparation machinery is of course working in similar proportion, and with equally good results, ring frames of 350 spindles each with front roller making 150 revolutions per minute, and spindles 10,000 revolutions per minute, for spinning up to 32's twist out of cotton similar to American. The above few particulars will no doubt sufficiently prove that the machinery of a modern Bombay cotton spinning mill is in every respect equal to the machinery of a Lancashire mill.

In the element of a cheap and abundant supply of labour, India has a great advantage, which as the work-people become more efficient will gradually become more marked. With increased efficiency, each individual workman will produce more and better work, at, of course, less cost to the manufacturer.

The cotton spinning industry of India is comparatively speaking only in its infancy, and is capable of almost indefinite expansion. India is capable of producing a practically unlimited supply of raw material suitable for manufacturing the coarse cotton fabrics used by the teeming millions of that country, to say nothing of the millions of pounds of yarns India annually exports to China there to be woven into cloth on hand looms by the natives of China for home consumption. The spinning and manufacturing of cotton in England's great Eastern dependency is making rapid strides, and in the near future will become in magnitude second only to the vast cotton trade of Great Britain, which has made its influence felt in almost every quarter of the globe. The manufacture of cotton yarns and cotton cloth in India presents a wide and rich field for English capital and enterprise.

At a meting of the Bombay Millowners' Association, Mr. Dinshaw E. Wacha said, amongst other things: "there had been a little depression of late, but there was a combination of circumstances which led them to hope that cheerfulness and prosperity were not far remote. It appeared from the statistics given in the report that China was consuming the cloth manufactured by Bombay mills in larger quantities, and the increase promised to go up by leaps and bounds. Whatever the Lancashire millowners might say or do, the geographical position of Bombay made it a strong and a healthy rival and competitor in the matter of piece goods in Chinese markets. The silver question had nothing whatever to do with the exports. Whether the price of silver went down to one shilling or rose to two shillings, their exports would go on increasing, because of the more certain conditions of the local trade, which would fetch better rates of yarn and cloth than Lancashire could ever expect to obtain."

The above view, coming from such a source, is strong confirmation of the fact that Indian competition with Lancashire is no longer an unknown quantity but a stern reality.

COTTON.

In the selection of cotton of the proper quality to make any and every description of cotton yarn, expert and practical skill, good judgment, and knowledge of the conditions and requirements of the cotton itself, as well as of its manipulation, are of the very first importance. These are necessary and essential qualifications when buying the raw material, for mistakes made here cannot afterwards be rectified, and must result disastrously when the cotton is passed into the mill to be carded and spun into yarn. To produce a certain given quality of yarn, the cotton must be of a correspondingly good quality and should not fall below the necessary standard if it is to give the all-important and desired result. Should it be deficient in quality, there will surely be a depreciation in the quality of the yarn, with a lessened production and a greater percentage of waste. These fundamental principles are thoroughly well known to and appreciated by all good spinners, who know better than to exercise any false economy on this head.

Cotton is generally distinguished by its colour, and by the length, strength, and fineness of its fibre; by freedom from impurities, and by evenness in length of staple. The more nearly it approaches this state of perfection the higher is the price it commands in the open market.

In judging cotton, the usual practice is to take up a small quantity of the wool and press it gently in the hand and between the fingers, so as to find out whether it is soft and silky or harsh and woolly, and watching how far the fibres are elastic, or become entangled. Then, with the forefinger and thumb of each hand, draw the cotton out, until a clear and distinct body of staple is got at, and until the fibres arrange themselves, through this process of "pulling," parallel to each other, so that you may judge of the average length and regularity. During this operation the regularity, length, strength, and fineness and smoothness of the material must be carefully noted. If the fibres are short, weak, and irregular, the cotton is of a poor quality and not worth much, as the spinning qualities of cotton depend, as before stated, on the length, strength, fineness, and elasticity of its fibres.

There are expert cotton buyers and cotton spinners whose touch is so delicate, that after glancing over the cotton with the eye and merely pressing a portion of the wool in the hand, they are able to arrive, with a great degree of accuracy and nicety, at a correct estimate of its qualities and worth. Again we say that it is of the utmost importance that the characteristics of th various kinds of cotton be thoroughly understood, they determine its value commercially. In colour, cotton is white, of a creamy tinge. Egyptians are both white and brown, and all cottons are more or less lustrous and pearly in appearance. The fibres in a natural state contain from 300 to 500 twists to the inch. In length the different cottons vary roundly from $\frac{1}{2}$-inch to 2-inches, and in breadth or diameter, according to the latest authorities, from $\frac{1}{1185}$ of an inch in Surat, to $\frac{1}{1562}$ of an inch in Sea Islands; thus it is seen that differences appear in the cottons grown in different countries. The fibres, when seen under the microscope, present a flat and ribbon-shaped appearance, and taper down to a fine point at the ends, similar to a needle.

Unfortunately, a great deal of cotton is picked before it is fully ripe, and is, on this account, deficient in both length and natural twist, besides which the canal running through the fibre is imperfectly developed. This latter imperfection deteriorates its value from the point of view of the dyer, as the cotton will not take or absorb the dye so readily and thoroughly as will cotton with the perfectly cylindrical tube which is present in fully ripe cotton. Unripe cotton is also deficient in natural twist or convolution, which again decreases its value considerably from the spinner's standpoint.

Sea Islands cotton is the most valuable of all cottons, and when seen under the microscope the fibres show themselves as twisted like a corkscrew. The more nearly cylindrical and the greater the spiral structure of the fibre the stronger and more pliant will they be found to be in spinning, readily entwining with and twisting round one another during the formation of a thread, gripping or intertwining the one with the other, and producing or giving strength, tenacity, and elasticity. There is a wide difference in the quality and value of the different varieties produced by the cotton plant. Sea Islands is the most valuable species, because it is only possible to spin the finest yarns out of a superior quality, with fine, uniform, long and perfect naturally-twisted fibre, such as Sea Islands affords. Short, irregular, coarse, and poorly-twisted fibres can only be spun into coarse yarn of inferior quality.

The strength of an individual fibre of cotton varies very materially. The best authorities are agreed in placing the different cottons in the following order, *viz.*, Surats, New Orleans, Pernams, Egyptians, Uplands, Sea Islands. Although an individual fibre of Surat cotton is stronger than one individual fibre of Sea Islands cotton, yarn of a given equal number spun from the latter is much stronger than yarn spun from the former. The diameter, of course, of a fibre of cotton must also be taken into account in relation to its strength.

It has been clearly demonstrated that Egyptian, relatively to its diameter, is the strongest cotton grown, but still, thread made from Sea Islands cotton is stronger than and of a superior quality to that made from Egyptian cotton; the former is in every essential qualification more highly developed and perfect. The cross section of a strand of thread of a given diameter or numbers spun from Sea Islands cotton contains a greater number of fibres than the cross section of a strand of thread, of the same diameter or numbers, spun from Egyptian cotton; thus, again, the greater number of the fibres of this high grade Sea Islands cotton, so richly endowed in every essential quality, produce collectively a stronger thread than one of the same bulk, made of the individually stronger Egyptian fibres, the latter not being so fully developed in convolute form or length.

The mechanical treatment to which the fibre is subjected in the various processes through which it has to pass from the raw material to the spun yarn, is very severe, and it is important that during these several operations the waxy covering should be preserved as far intact as possible. When, however, the manufactured cotton is subjected to the dyeing and bleaching processes, the wax and natural oil must be removed, or boiled out, so as to allow the dye to penetrate the fibre.

An explanation of the heat and humidity which is required in spinning is that the waxy substance natural to the cotton is thereby softened, while the flexibility of the fibre is maintained. The temperature and humidity for good spinning should be respectively from 75 to 85 degrees of heat and 65 to 75 degrees of density.

It is a common practice with some spinners to mix two or three different kinds of cotton together, whereby they claim to get better results in both quality and economy. The advocates of this system place great importance on what they are pleased to call the skilful blending of dissimilar (?) cottons, insisting that the better quality is made to conceal the defects of the poorer or inferior cottons. With this theory and practice the writer is entirely at variance, taking the strongest exception to it; a long, varied and practical experience having proved to him that this system is radically wrong.

We advocate and practise the opposite course. Common sense alone teaches that cottons of different staples or fibres in length, strength, diameter, and convolution will not, and cannot incorporate to advantage, nor can a uniform, level and even yarn be produced when cottons of opposite characteristics are worked together. The author desires to draw particular attention to, and invite criticism on this subject and these remarks. On well defined lines certain uniform and equal cottons will produce certain uniform and equal results, but the moment we deviate from the fundamental principle that cotton should be as uniform in quality as possible, so surely do we destroy the very foundation upon which alone it is possible to produce a thread of yarn of uniform solidity, as well as one round, even and strong.

In the trade the many different varieties of cotton wool are known by the names of the countries or districts where they have been grown. The largest supply of cotton comes from the Southern States of the American Union, British India, Egypt, and the Brazils in the order named, and in all these countries the cotton plant is cultivated to a great extent.

Sea Islands cotton, as is well known, and as before stated, is the most valuable of all cottons, and is principally used for the production of the finest fabrics and superior thread-yarns. A great deal of this superior wool is also used now to spin coarse counts of yarns which take the place of linen threads.

Egyptian cotton ranks in price and quality next to Sea Islands; it is also a very superior wool, of a brown tawny colour, with a long and strong staple, but not nearly so fine and silky as Sea Islands. It is chiefly used for the production of medium and medium-fine numbers.

The Brazilian varieties also stand high in the market, and rank next to Egyptian. American peeler and long-stapled Allan seed cottons are now quite extensively grown, and are held in considerable favour by some spinners, especially in America; but there is in many quarters a strong current of contrary opinion regarding these varieties, on account of their being ginned on the saw gin; in consequence of which the fibres are considerably damaged and broken up, the staple is weakened and the cotton is made very wasty. These particular brands of American cotton are also very irregular.

The ordinary brands of American cotton, Uplands, Savannah, Mobile, Texas, etc., are fine, soft white cottons, and are in great demand for general use at 32-36's. They are well adapted and generally used for making calicoes, velvets, or fustians.

The British India, or Surat cottons, are of a lower quality altogether, but are very extensively cultivated. This class of cotton is used for the lower qualities of yarn and cloth.

In India the Bombay mills use the native wool exclusively, and the average counts spun are 20's to 24's soft twist. This is largely exported to China, where it is woven by the natives on hand looms for home use If we want Indian cotton for nothing else, we want it as a set-off against the gigantic system of American cotton gambling, which is referred to later on.

The adulteration of all cottons, but more especially American, with sand, water, and other fraudulent substances, is carried on to a great extent, and entails a heavy loss upon the spinner. No apology, therefore, is considered necessary in giving prominence to this evil.

First. Cotton in the same bale is often of different staple or fibre. When the colour of the cotton is uniform, want of proper sorting or over-ginning will probably account for this, but when the cotton is found in layers of different grades or qualities, as is too often the case, the general opinion is that it is the result of fraudulent admixture of different kinds of cotton, and does not arise from careless sorting. The even grading of cotton is very important, and there is much room for improvement in this respect in a great deal of the cotton received, more especially from America. A better grading of cotton would be secured if the plan of careful inspection by first purchasers were enforced.

Second. There is a large percentage of unnatural damp in American cotton, and no other cotton loses weight in this respect like American does. It is a common thing for this cotton to lose ten per cent. in the process of drying. There can, unfortunately, be no doubt that water is fraudulently added to the cotton to augment its weight.

Third. Another source of heavy loss in America cotton is the large amount of dust and sand found in it and thousands of tons of fine white and red sand ar annually purchased at the price, and in place of, th wool itself. Complaints on this head are more gener than the complaints in regard to the mixing and dam ing of cotton, and are likewise of a far more serious character.

This crying evil of the adulteration of cotton is a question that has for a long time past received the serious attention of cotton spinners, but, unfortunately, the evil continues to exist, and nothing, it would appear, has yet been enforced to even check, let alone stop, these frauds.

In the buying of cotton the spinner should deal only with the best houses, and he will then have as good a guarantee as it is possible to get that his cotton will, at the least, be as carefully selected and as free from adulteration as circumstances permit. He should likewise strictly insist upon the close, careful, and thorough examination of every bale of cotton that enters the mill, and should never tire in bringing before the proper parties any and every legitimate complaint he may have; he will then, at all events, have the satisfaction of knowing that no effort on his part has been wanting to secure the raw material in the best possible manner and condition. It is also wise to, as far as possible, confine the buying of the cotton to one broker or house; the writer knows of one large firm of spinners, second to none in the world, who uniformly adopt this plan, and who thus obtain, week in and week out, uniformly good and remarkably even-running cotton, and comparatively free from the fraudulent abuses referred to.

A wise cotton spinner will, at all times, and under all circumstances, avoid buying futures or speculating in the raw material, and will confine himself to the legitimate requirements of his business as a spinner in all his operations in cotton, otherwise the inevitable crash will sooner or later overtake him, as it has so often and relentlessly overtaken, and will continue to overtake and ruin, all those who gamble in the raw material. In this connection the following incident may be worth relating: When quite a young man the writer was engaged for a time with one of the greatest speculators or gamblers cotton has ever known, and this firm, through persistent, untiring, and determined efforts, "roped-in," as they say in America, one of the principals of a firm of extensive and wealthy cotton spinners, and induced him to speculate in futures. From a small beginning they got him deeper and deeper into their clutches, till at last he was completely at their mercy, and ruin seemed inevitable. He could not throw off either the leeches or the fever that was consuming him, mentally and financially. To save him and his fortune from utter destruction, a family conclave was held, and his friends induced him, as a father and a man of honour, to sign a pledge on his solemn word of honour that he would never again gamble or speculate in cotton. Notwithstanding this, the speculators did not relax their efforts upon him, but he kept his promise to his family, and escaped from their meshes all right. This incident, which occurred some twenty years ago, made at the time a strong and lasting impression on the writer's mind, and he has thought it well worth repeating here as a warning to the rising generation.

The exaggerated reports that come to hand so persistently and regularly during the growing season from interested parties and speculators, regarding short crops, drought, diseases, etc., etc., should be taken with a very considerable grain of salt. The circulation and dissemination of such rumours have become chronic, and have come to be regarded as little, if any, better than lies. These stupid concoctions are not likely to mislead a cautious, observant and intelligent cotton buyer; they are an insult to the trade, and a reflection on the sagacity and honesty of their originators.

In connection with this subject, attention is drawn to the following, *viz.*, the cotton caterpillar, and rust in cotton.

THE COTTON CATERPILLAR is a worm about 1½ inches long when full grown. It makes its appearance in countless numbers. The first brood does little or no damage. The second is more destructive, and the third destroys all the leaves and young bolls. It is usually about three weeks from their first appearance till the third brood is hatched out. They first denude the plant of its leaves, and then eat the "shuck" off the young bolls, which stops their growth. They may open, but the cotton is worthless. After the third brood is hatched, it only requires three or four days to destroy all the leaves in a large field.

THE RED BUG simply stains the cotton, but does not otherwise injure it.

RUST is a species of blight usually caused by very hot, dry weather following a rainy season. The growth of the plant is stopped, its colour changes from green to a reddish brown, and the "forms" and "squares" are thrown off. The young bolls rarely mature. In a word, when cotton has rust, little more can be expected of it than the product of the grown bolls.

TO SUMMARISE.

SEA ISLANDS.—This is the finest cotton grown, of a creamy tinge and fine silky nature, with a long and elastic staple, and well-developed in natural twist or convolution; the average length of the fibre is 1·75 inches.

EGYPTIAN is a very superior cotton, brown or tawny in colour, with a long and strong staple, but not so fine or silky as Sea Islands; the average length of the fibre is 1·45 inches.

BRAZILIAN and **PERNAMS** are of a superior quality and rank next to Egyptians, of a rich cream colour and wiry in nature; average length 1·25 inches.

AMERICAN PEELER and **ALLAN SEED** are of doubtful and changing qualities, white in colour and irregular in staple, wasty and considerably damaged in ginning; average length 1·50 inches.

NEW ORLEANS.—A superior clean cotton, soft, glossy, and silky, even running, and naturally well-developed; average length 1 inch.

TEXAS UPLANDS and **MOBILE.**—Fair coloured, short stapled, and good cottons for spinning weft and filling; irregular both as regards staple-cleanliness and general quality; average length under 1 inch.

EAST INDIAN cottons are of a low quality and short in fibre.

HINGENGHAUT has a strong, fine fibre, free from leaf, and does not contain much other dirt but seeds.

OOMRA is a dry, leafy cotton.

BROOCH.—Soft, silky fibre, and glossy in appearance; good for weft or filling.

DHOLLORAH is a very dirty cotton, of a longish staple. When cleared this cotton is very white, as if bleached.

DHARWHAR.—Dull, dark brown, neppy cotton.

CENTRAL ASIAN, or **PERSIAN**, and **BUCHARIAN** cottons are of a harsh, woolly nature, with a short and weak fibre and very full of seeds and shell.

The cottons produced in the United States are generally ranked as follows:—

Extra fine Islands, fine Islands, medium fine Islands, etc.

Various brands of common American, good middling, middling, low middling, and ordinary.

Brazilian, or South American: Good, good fair, mid fair.

Egyptian: Good fair, fair.

East Indian: Good, good fair, fair.

As the capabilities and uses of all cottons are so very varied, and are nowadays spun into all manner and numbers of yarns, to have here considered any fixed or narrow list of what any particular class of cotton should or may be spun into, would only be misleading, and is, therefore, not given, as liable only to confuse.

The vast importance of the interests involved in the cotton trade all over the world are so momentous that we ought not to depend on any particular source for a supply of the raw material. A series of bad seasons in the great American cotton belt would reduce many flourishing manufacturing towns in different parts of the world to ruin and beggary. Were the Americans to reduce the area of cotton plantations—a matter which has more than once been seriously talked of; or, again, were a failure of grain crops to occur in some other part of the world, which would induce Americans to grow grain instead of cotton, the trade would be very seriously embarrassed. While, on the one hand, Egypt, under very favourable conditions, is capable of supplying all our wants in the particular styles of cotton which that country produces, on the other hand, the preponderance of adverse conditions—war, locusts, worms, pestilence, and the vagaries of the Nile, render the supply of cotton from that country too precarious for the cotton interests in the manufacturing countries of the world to rely upon it. The natural and logical inference to be drawn, therefore, is that the cultivation of similar qualities of cotton should be carried on in different cotton-growing countries, so that a famine of either American, Egyptian, or Indian cotton might not produce financial disaster to the trade, and bring desolation on the many householders depending on the manufacturer.

MIXING.

The first thing to be done with the cotton on its arrival at the mill is to draw, say, two samples from every bale. These samples, in the first instance, should be compared with the samples received from the broker from whom the cotton has been bought.

If upon comparison it is found that the cotton received is not up to the mark, or not fully equal to the buying samples, the cotton should be at once rejected, and the fact immediately reported to the buyer or broker. The most careful attention should be given to this all-important matter, for it is undoubtedly of the very first importance that the cotton be fully up to sample. This should ever be kept in mind as a leading principle, for it is a well-known fact that good even-running cotton, which is the very foundation of the business, and upon which depends good regular yarn, is fully half the battle. The spinner devoting—as all good and leading spinners do—any extra care and attention to this department, is fully and amply rewarded, both in the working of the cotton in the mill, and in the quality of yarn produced.

Another and equally important reason for thorough and careful examination of every bale is that the cotton may be classified according to the numbers and quality of yarn required, the price at which the yarn is to be sold, and according to the machinery upon which it has to be carded and spun.

The sorting and grading of cotton cannot be too minute and searching, and the person entrusted with the duty should be a good judge of cotton, and practically acquainted with the results to be obtained from the various grades and qualities of the raw material.

It is desired to make a very strong point regarding the examination and classification of the cotton, and we again repeat that no man, unless he has had a long and practical experience in handling and working it, should be entrusted with this important duty.

Assuming that the cotton is now graded and classified for the various mixings, the next thing to be done is to pass it through the bale-breakers. It may here be stated that it has now become the universal custom to pass all cottons, from Surat to Sea Islands, through this machine; it may also be emphatically stated that the bale-breaker does not in the least injure the cotton—on the other hand, the operation is beneficial, much of the heavy dirt and seed being got rid of, which considerably relieves the opener and scutchers. This is especially beneficial in respect to the seeds, which it is important to get rid of as far as possible, before they get broken up in the callender rollers of the scutcher, and go forward in the laps to the carding engine.

When first taken from the bale, the cotton is closely matted together in hard lumps, and the bale-breaker loosens it nicely, so that, after passing through the machine, it is in a comparatively free and open condition for mixing, which in itself is a great advantage, as a better mixing is ensured. The machine also is a labour saver.

As cotton, even in the same bale, is found to vary more or less, it is necessary, before mixing, to open up as many bales as convenient, and when putting the cotton through the bale-breaker a certain quantity should be taken from each bale, so as to get as thorough and perfect an incorporation of the whole as possible. By this means a more regular and even-running mixing is secured, and the element of variation is reduced to a minimum.

It is not only advisable but very necessary to make the mixings as large as possible; the greater the number of bales put into a mixing, the better it is, for, as before stated, the variation in the different bales is quite considerable, and unless they are thoroughly well mixed together in large lots it is impossible to make a yarn of uniform quality. Again, a large mixing that will last, say, some weeks, is a fair· guarantee that as long as the mixing lasts the yarn made from that mixing will be as regular in counts and uniform in quality as it is possible to make it. Every time a new mixing is made, however fairly even-running the cotton as a whole may be, some slight variation in regularity and colour is the result. To avoid or minimise thisas far as possible, small mixings should be avoided. All this is well known as a fact, and it is likewise a well-recognised principle to make as large mixings as possible; nevertheless the above rule will well bear repetition and emphasis.

In a previous edition we have said :—

"To make up a stack of cotton is a matter of very first importance, and should never under any circumtances be left to careless hands or to those who are ignorant as to the serious results of bad mixing. When making the mixing, the bales that are to be mixed should be brought forward one by one, opened, pulled into small pieces, and spread out equally over the whole surface of the mixing, beginning at the bottom and so on alternately, layer above layer, and should be trampled down exactly in the same manner as building a haystack.

"When it is required to use the cotton it should be taken from all round the mixing, cut as it were from top to bottom.

"The cotton to be mixed should be as nearly equal in length of staple as possible, for when short and long cottons are mixed together, the yarn is sure to be unequal and uneven."

Richard Marsden, in his excellent work, says:—

"Where different kinds of cotton are mixed together, the greatest care should be exercised in the selection of the staples, so that they may all be of one length, or as nearly so as possible. If short and long staples are put together the result will be excessive waste and poor yarn. To combine the highest quality in the product with the greatest economy of production requires that long, short, or medium lengths of staples should each be worked by themselves."

Nasmith, in his standard work on modern cotton-spinning machinery, says:—

"The principle is, that to spin a good yarn it is necessary to use cotton in which the fibres are of approximately the same length. It is impossible to lay down any definite rule as to mixings, the production of which is a matter of experience."

Messrs. George Draper & Sons, of Hopedale, Mass., U.S.A., in their useful and descriptive catalogue, say:—

"Whatever method of grading the stock (cotton) is adopted, it is of the greatest importance that the mixing should be carefully made, and any bales that are manifestly of too long or too short a staple to work with the grade that is being used, should be laid on one side, to be worked when a sufficient quantity has been collected to make it an object, or they may be disposed of in any way except in attempting to make good work with a mixing of widely different stock."

An eminent firm of Liverpool brokers give their opinion as follows :—

"It is not easy to set up any exact standard of cotton to spin counts of a given number, for the reason that there is no uniform practice among spinners, some men using cotton altogether better and dearer than others, though apparently competing with yarns of the same quality, or at any rate of the same numbers. Further, a wide discrepancy obtains between the qualities of different yarns of the same numbers."

Every new lot of cotton should be tried to see what percentage of loss it contains. A certain quantity is taken from the middle of each bale until say 100 lbs. is got together; it is then put through the opener and scutcher. The insides of these machines are thoroughly well swept out and the cotton is then put through them, after which it is again taken and weighed, and the machines are once more swept out and all the droppings, dust, sand, seeds, etc., that have come out of the cotton are collected and weighed separately. These results are entered in the loss book opposite the mark of the cotton, so that at any time it may be seen what the first loss is in the different kinds of cotton. It is also advisable to make occasional trials of any large lots of cotton right through to the yarn.

Enough, it is thought, has been said in this short notice, without creating confusion in the mind of the reader, to prove the very great importance attached to the grading and mixing. This department, upon which depends so largely the success or otherwise of the business, should receive the constant care and attention of the manager.

COTTON SPINNING MILLS.

When about to embark in the business of cotton spinning, every point in connection with the project should be duly and carefully considered, and not the slightest matter bearing upon the question should be lost sight of. The first and most absolute necessity is ample funds, without which a first-class mill, substantially built on the latest and most approved plans, and equipped with the best and most perfect machinery, cannot be produced. There must also be an extra cash balance in hand for working capital, which Nasmith in his excellent work on modern cotton-spinning machinery says should be 20 per cent. of the fixed capital in England, and proportionately more in other countries. To attempt such an expensive undertaking as the business of cotton spinning with deficient capital is only courting a disaster which will surely and speedily follow.

Assuming that the financial question is satisfactorily settled, it must next be determined in what particular district to locate the mill.

In England, of course, it will not take long to decide this question. Manchester is the centre around which spinning and manufacturing is carried on; Oldham for coarse and coarse-medium; Bolton for medium and medium-fine; Manchester and vicinity for fine and extra-fine.

In India, Bombay is the great centre.

In the Russian Empire a large proportion of the spinning is carried on in the Petersburg and Moscow districts, while there are many mills scattered in different parts of Central European Russia. The town of Lodz is the cotton-spinning and manufacturing centre of Russian Poland.

In the United States of America the industry is pretty generally spread over the New England or Eastern States, with Fall River and New Bedford, Mass., as the cotton spinning centres. Of the Great Western Republic, New Bedford, Mass., is becoming the centre for fine spinning. The atmosphere of this particular locality, affected as it is by the Gulf Stream, and being thus naturally warm and humid, is well adapted for fine spinning.

Cotton is now successfully spun in countries subject to such widely different climates—the humid atmosphere of Lancashire, the hot saturated atmosphere of India, the cold, arctic and dry climate of Russia, and the changeable and variable climate of the United States, that it is evident that altogether artificial conditions nowadays go far towards overcoming climatic influences of an adverse character. Cotton spins best in an atmosphere naturally warm and humid; therefore it is most desirable, other circumstances permitting, to locate the mill where Nature has supplied this all-important aid to good spinning. This question of climate and atmosphere has solved itself so far as England, India, and America are concerned, the bulk of cotton spinning having found its way to the districts provided with the most naturally moist and humid atmosphere. Where Nature has not been so bountiful in this respect, man has come forward to supply the deficiency as far as possible, and in no other country has this matter received as much study and attention as in the United States. Necessity is the mother of invention, and in America, where the temperature and humidity are very changeable, the necessity for the adoption of some method to enable spinners and manufacturers to overcome the almost daily atmospheric changes, is undoubtedly felt more than in any other country (with the exception of Russia) where cotton spinning is conducted.

The inventive genius of the Americans has come to the rescue, and a suitable temperature and humidity is to-day produced by artificial means to a wonderfully perfect degree. There are several such systems working well, and giving very satisfactory results; amongst them may be mentioned the Garland, the Aerophon and the Sturtevant. The latter system, combining in one, as it does, both requisites—heating and moistening in the winter, and cooling and moistening in the summer, is undoubtedly the best and most perfect system yet known. One great advantage of the Sturtevant blower is that it is constantly forcing fresh air from the outside into the mill. We speak from actual experience in this matter, and can guarantee that it is not only possible, but quite easy, to completely saturate the air in the mill in a few minutes on the driest day. Again, the fresh pure air that is forced into the mill is of the utmost importance and benefit to the workers; their health is better, and they are consequently enabled to attend to their work more regularly and to execute it in a more satisfactory manner.

This system of continually supplying fresh air, of heating or cooling it, and at the same time moistening it, might with advantage be adopted in Russia, and is, we note, now being adopted in Lancashire in both spinning mills and weaving sheds, and may be described as follows: "The engine being started, a large fan draws the fresh air from the outside through the heater, by which it is warmed to the desired temperature. The air then passes through the humidifier, where it gathers up its moisture from pure fresh water or steam, according to the season of the year, and travels up an oval pipe into the main pipe of each room, and thence through the branch pipes into the rooms. Valves are placed at each main, and at each branch, so that a room, a branch, or any portion can be shut off or on as required." The Sturtevant system, comprising as it does the three principles in one, namely, ventilating, humidifying and heating, and performing all with simplicity and effectiveness, is undoubtedly the system of all others to adopt.

In deciding upon a neighbourhood in which to commence the manufacture of cotton, it is advisable also—though not absolutely necessary—to start one in or near the cotton-spinning centre, so that you may be on an equal footing with your competitors, and able to command a fair share of trained and experienced hands; for where labour is scarce, or of an inferior or low order, the article produced will be of an inferior quality, and as a matter of course will not command either a ready sale or a good price. The production, also, will be below the mark, and as so very much in the success of a spinning mill depends upon the spindle point, the mill where the production is low will be handicapped with a heavier proportion of fixed expenses ; the waste and the wear and tear of machinery will be excessive also ; and it will readily be understood that an adverse combination of this kind will not permit of competition with mills yielding a high average. In a word, success or failure depends upon production, which must be kept up to the highest possible point. A good class of experienced and trained operatives can undoubtedly help to achieve this desirable result. On the other hand, however, it has unfortunately been too often the case that the hands, knowing this, and feeling themselves all-important, have handicapped the mill by not allowing the full and legitimate production to be taken off. When such deplorable conditions as these exist, it has been found necessary by employers to resort to radical means to eradicate the evil, by getting rid of such an undesirable element, and putting in their places others of perhaps not quite equal skill, but out of whom, with care and attention, equal and even better results have been attained. Again, in some countries where cotton spinning is in its infancy, there is no such thing as trained or skilled help, none but the overseers and leading hands being proficient. Strenuous attention, perseverance and determination on the part of the leaders soon overcome all difficulties, and with the wonderfully perfect and self-acting machinery of to-day the so-called (and over-rated) skilled help, although a valuable adjunct when guided and influenced by reason, is found to be not by any means at such a high premium as in former times.

Another very important point to remember in deciding upon locality is the fact that it will be of great financial advantage to be located in a spot or district where water and railroad carriage are to be had, the cost of carriage being a larger item of expense. As proof and example of this, it may be pointed out that in two well-known and leading mills in America, one, situated on the bank of a navigable river, secures its coal at 1¼ dollars per ton less than the other, which is less favourably situated, not being accessible by water. All the coal has to be carted from the railroads, which are likewise some distance from the mills. The raw material and finished products are likewise subject to the same extra tax. At the end of twelve months the charges for carriage in the case of the mill thus handicapped amount to quite a heavy tax, which the other mill, accessible by water, has not to contend with. This question of carriage is an extremely important one, and should be duly considered when deciding upon location.

Again, it will be of great advantage to build in close proximity to an abundant and never-failing supply of good soft water for feeding the boiler and for dyeing and bleaching purposes; this of itself is a most essential point, and alone is of almost sufficient importance to decide the question of site.

Regarding the material with which to build the structure. Bricks are most commonly used all over the world, being perfectly durable and at the same time costing less than stone, unless in some particular instance where the latter is abundant, as is the case in certain parts of Lancashire.

With respect to the system of construction, there are, broadly speaking, but two; the one so-called fire-proof, the other non-fireproof, or slow burning. In Europe all the modern mills are built on the former plan, with cast-iron columns and iron or steel beams and joists; in England the floor is made of concrete and on the Continent of brick vaults, the whole being covered with wooden flooring to receive the machinery. In America they prefer the system of semi-fire-proofing by thick wooden planks, the joint being broken by a hard wood layer, while the columns are of cast iron.

On this question of construction Mr. Dobson, of Bolton, a high and valued authority on all matters relating to cotton mills, speaks as follows regarding the American style of floor:—"I am strongly of opinion that it would not be a good thing to depend entirely upon the inside framework to prevent and absorb vibration. Where there is a large amount of oscillating machinery, such as looms, combers, mules, and any machinery in which large bodies oscillate, there comes a time when the oscillation is synchronous, and in England we trust to the wood and the stability of the walls to absorb and nullify the vibration caused to the floors and columns by this oscillation. I noticed when in America, in several buildings where looms were placed on the upper floors, that occasionally the whole or a greater portion of the slays would be moving in the same direction at the same time, and I have felt the building vibrate in a manner that would cause great perturbation to Englishmen accustomed to the solidity of our buildings. I cannot help thinking that on the whole it would be better and cheaper to have thicker walls than is generally the case in America, on account of climatic influences. Anything I have stated with regard to iron columns and beams would also apply to wood, providing the beams were strong enough."

The following is a description from the Manchester *Textile Mercury* of a typical modern Lancashire mill containing about 108,000 spindles, 56,000 weft and 52,000 twist; one half weft and an equal proportion of twist from double roving, which of course necessitates extra preparation machinery in the card room. The concern is set out for spinning 70's, making a twelve-hank roving. The mill is said to comprise the largest card-room in the world under one roof, and holds 120 cards and all preparation machinery to follow.

"The machinery includes bale breakers, mixing lattices, exhaust openers, intermediate and finisher scutchers, revolving flat carding engines, drawing, slubbing, intermediate and roving frames, and 45 pairs of self-acting mules. The building is 272 feet in length by 133 feet in width inside, and five storeys in height, in addition to the basement, which extends under the whole of the building. It is divided in its length into two unequal parts by the rope race. The first storey contains the blowing room in the short end, and the card room in the long end, the extent of the card room being increased by a side shed 210 feet in length by 28 feet in width, containing two rows of carding engines and enabling the whole of the carding and preparing machinery, as well as the blowing machinery, to be placed in the first storey.

"The basement extends under the card shed as well as the main building, and iron columns are used between the shed and the main card room, to carry the wall of the upper storeys of the mill, thus making the shed and the main card room one room.

"The shed roof, which is made of concrete and is fireproof, slopes down against these columns about 8 feet from the floor line, and continuous lights are fixed along the upper part of the columns, giving a direct light to that portion of the room in the main building, which is always much darkened when brick butts are used to carry the mill wall above. The second storey contains the cotton and mixing rooms in the short end and a spinning room of nine pairs of mules in the long end. The third, fourth and fifth storeys each contain three pairs of mules in the short end, and nine pairs in the long end, making 45 pairs of mules in the mill. The basement contains warehouse, conditioning cellar, waste-cellar and dust-cellar. The staircase projects from the front of the mill opposite the rope race.

"The engine house projects from the back of the mill centrally with the rope race, and the boiler house is placed in the corner formed by the back of the short end of the mill and the side of the engine house. The offices are a separate building. The whole of the buildings (with the exception of engine house, boiler house and office roofs) are fireproof throughout on Messrs. Stott & Son's patent principle, with cast-iron columns, steel girders, and brick arches of 7 feet span.

"The conditioning and waste cellars have floors of cement concrete, paved with Messrs. Stott's special bricks; the warehouse, blowing room and card room have floors of Rochdale polished flag, except in the card room, where the drawing, slubbing and intermediate frames are placed, where the floor is boarded with 1½ inch white deal boards, covered, after the machines were fixed, with ¾ inch birch boards. These latter do not wear, and save considerable expense in repairs to frame cans. The cotton and spinning-room floors are boarded with 1½ inch white deal grooved and tongued boards, the sleeper joists being bolted down to the steel girders, and 2½ inch continuous planking placed under the head-stocks, each plank being bolted down. The engine house has a dado 7 feet high of buff glazed bricks, with moulded base, neck mould and cap mould in colours to harmonise. The walls above the dado are faced with pressed bricks and painted in two shades of salmon colour. The walls have projecting piers, with stone caps, which carry the girders of a 15-ton travelling crane.

"There are four Lancashire boilers, each 30 feet long by 8 feet diameter, constructed of selected mild steel to carry 120 lbs. per square inch working pressure. The feed water heater, or fuel economiser, contains 480 pipes. There is a large duplex donkey and fire-pump, and other appliances will be supplied—consisting of a fire-escape at each end of the mill communicating with each storey; pipes up the staircase and each fire-escape, with hydrants and valves at convenient points, and the necessary stand-pipes, hose-pipes, and fittings.

"The steam engines are two coupled engines of the compound horizontal tandem type, constructed for a stroke of five feet, and intended to run 55 double strokes per minute. The fly-rope drum is placed between the engines, and is 30 feet diameter, grooved for 48 ropes each of 1⅜ inch diameter. The crank shaft is of Siemens-Martin steel, and has bearings 36 inches long by 16 inches diameter, and single cranks one at each end fixed at quarter centres with each other, and fitted with steel crank-pins 10 inches in diameter. Each crank shaft pedestal is a massive casting with broad base resting on, and bolted down to, the stonework, and connected to the low-pressure cylinder by a massive frame of the Corliss type, with a separate flat slide above and below the cross-head. The low-pressure cylinder of each engine is 49 inches diameter, and behind each, and connected to it by distance pieces and bolts, is a high-pressure cylinder 23 inches diameter. All the valves are piston valves, which require a minimum of power to move them, and have extra large ports and passages. The supply of steam to high-pressure cylinders is automatically regulated by a patent cut-off, the governor (without throttle valve) acting through a trip motion which partially twists round the valve and cuts off the steam earlier or later according to the load on the engine. The piston rods, valve rods, and connecting rods are of Siemens-Martin steel; the connecting rods have solid ends at the crank-pin end, and marine ends at the cross-head end. The air pumps are vertical, of short stroke, and worked by connecting rods and bell crank levers from the crank-pins."

The following, likewise taken from the *Textile Mercury*, is a description of a pair of triple-expansion engines for driving one of the newest and most modern Lancashire mills:—

"The new engines are similar to the old ones in very many respects; the power 1,200 indicated horse power, the speed 50 revolutions per minute, the stroke 6 feet, and the size of the fly pulley 28 feet diameter, grooved for 35 ropes, being the same in both cases, the great difference between the two being in the boiler pressure. The old engines work with 80 lbs. boiler pressure on the compound principle; the new engine at 160 lbs. on the triple expansion principle. The old engines have worked economically, but it is anticipated that the new engines will work with a considerably smaller consumption of steam. Instead of two cylinders, the new engines have four, one high-pressure cylinder 22 inches diameter, one intermediate cylinder 31 inches diameter, and two low-pressure cylinders 35 inches diameter. These are arranged like the cylinders of a pair of tandem engines, the high-pressure cylinder being placed behind one low-pressure cylinder, and the intermediate cylinder behind the other. The adoption of four cylinders for a triple-expansion engine has great advantages, as the engine not only has a symmetrical appearance, but the powers and the strains on the two cranks are maintained very nearly equal. By dividing the low-pressure cylinder into two, the disadvantage of having one very large piston is got rid of. The low-pressure piston in the No. 1 mill engine is 58 inches diameter, as against two pistons only 35 inches diameter each in the No. 2 mill. The valve gear of this engine is of the Corliss type. The piston-rods, the cross-pins and the crank-pins are of Siemens-Martin mild steel, as also are all pins throughout the engine subject to wear; the cross-heads, connecting-rods, cranks, and the crank shaft are of scrap iron, the last being 15 inches diameter in the journals and 20½ inches diameter in the swell for the fly-wheel. The condensing apparatus consists of a condenser placed between the engines, into which both the low-pressure cylinders exhaust, and two air-pumps, one driven off each engine cross-head. The engines are provided with all the latest improvements in the way of automatic lubricating apparatus; the cylinders are cased with sheet steel; and the fly-wheel is provided with a wood casing."

For motive power, steam is almost universally employed all the world over. Corliss engines of the compound horizontal tandem type have taken the place of high-pressure condensing engines. The triple expansion system, however, is now coming to the front, and even the quadruple expansion is already making headway. Steam at 160 lbs. pressure to the square-inch is used for the triple expansion, and as high as 200 lbs. for the quadruple expansion. Steam of 120 lbs. pressure is used for the compound tandem type.

The most generally accepted boiler is the two-flued Lancashire, with Galloway tubes 30 feet long by 8 feet diameter. This style of boiler undoubtedly takes the lead in general favour, and may be safely recommended as the best and most economical for mill purposes. Whatever type of either engine or boiler be adopted, there should always be in both instances plenty of spare power.

For the transmission of power, Richard Marsden, in his incomparable work on cotton spinning, says, "The system of transmitting power by means of ropes is in first cost fully 30 per cent. less than either gearing or belts." We know that it is now universally adopted in England, Russia, and India. The two latter countries are governed in the construction and management of their cotton mills by the English system of mill management and construction, and will undoubtedly have accepted the system of transmitting power by ropes in preference to either gearing or belts, on account of its having proved so satisfactory in England, to which country they look for both advice and guidance in all such matters. In America, however, it is different. There they act more or less independently of outside opinion in all matters, and more in accordance with the dictates of their own judgment and convictions. As proof of this we find that in almost all, if not in all the cotton mills in the United States, belts are adopted in preference to ropes for the transmission of power.

The writer has had considerable experience in both rope and belt driving, and favours the former system for the following reasons. First, the loss of power through friction is fully 10 per cent. more where belts are used instead of ropes. Mr. Dodge, an American authority on this subject, in a paper read before the New England Manufacturers' Association at Boston, in October, 1890, claims that there is a saving of fully 15 per cent. of power in favour of ropes over belts. Second, where belting is used there is more or less considerable slippage—whereas if the ropes are of sufficient capacity and of fairly equal tension, this slippage is overcome. Belts are more affected by damp or wet weather than are ropes, and become very slack, thus causing slippage, with much loss of power and decreased production in the mill. These two items—loss of power through friction, and loss of power through slippage, are of themselves, in the writer's opinion, sufficiently important to give the preference to ropes. Again, there is the extra heavy first cost, which is so much against belts, being fully 30 per cent. The American authority previously quoted, Mr. Dodge, agrees with the English authority, Mr. Marsden, on this question of first cost. It must also be borne in mind that it is daily becoming increasingly difficult to procure belting of first-class quality, from the fact that the cattle on the western plains of the United States of America are nowadays killed off in immense numbers at a much younger age than formerly, and their hides consequently have not time to mature. That this is the case we are assured by the largest belt manufacturers in the United States. This element of itself would appear to be sufficiently serious to call a halt in favour of rope driving.

The following are extracts from the paper previously referred to:—

"The facility of taking small powers off pulleys to machines by means of belts, and the absence of noise and vibration, led to the adoption in the United States of America of broad leather belts for the transmission of large powers from the prime mover to the shafting in factories, but the mechanical difficulties attaching to transmission of large powers by means of large belts have for a considerable time interested mechanical engineers in efforts to find a satisfactory substitute. Hemp and cotton ropes have been employed in England for several years. The distinguishing feature of the English system is the duplication of individual ropes when the power to be transmitted exceeds the capacity of a single rope of that convenient size. It is evident the diameter of the rope is an important factor in rope transmission, because in passing around the terminal wheels the effects of flexure are in proportion to the diameter of the rope. In the English system, when the power to be transmitted exceeds the capacity of one rope, another rope is added, and so on. This system has several disadvantages, among which are prominent the impossibility of securing uniform tension on the several ropes, and the multiplicity of splices. Nevertheless, it is quite extensively used in Europe and in the East, though it has not been received with equal favour in America."

"The American engineer has preferred the wide flat belt to the English system of duplicate ropes. The modern growth of mechanical science in America has, however, led to many experiments looking to an avoidance of the cost and mechanical losses attending the wide belt; the outcome is the distinctive American system of employing only one rope, however many wraps may be required, to transmit the given power, and by a system of winders the ropes pass the terminal wheels as many times as may be required to secure complete adhesion and entire avoidance of slip."

"The most preferable form or angle adopted for the groove in the pulleys transmitting the power by rope is the U.S. standard V thread angle of about 60 degrees, allowing the rope to bind firmly on both (or two) sides, and at the same time lifting easily out of the grooves, without any stick or hang, after having done its work. It is also assumed to be safe to use from 2 to 3 per cent. of the breaking strain of the rope."

After reviewing the various systems of driving referred to above—the old and obsolete plan of gearing, with its noise, dirt, and liability to breakdowns, with their attendant loss and anxiety; the plan of driving by belts, with the loss of power and extra first cost, etc.; and the American plan (complicated) of one single rope, with the risk and danger attaching thereto through being dependent upon only one factor, as it were, we must admit that the English plan represents the safest and all-round generally the best system of the lot.

It is self-evident that the English system of duplicate ropes is the one containing in itself a maximum combination of the best qualities with a minimum of disadvantages—reliability, safety, and economy, as against the doubtful and risky advantages claimed for the American system. Taking everything into consideration, we unhesitatingly pronounce in favour of the English system of rope driving, as against the three other systems referred to.

To summarise in the excellent conclusions of Richard Marsden: The locality must be well chosen; the site of the mill carefully selected; the mill well constructed; the machinery must be of the best for its particular purpose; and the management must be skilful, economical and thoroughly honest. Technical, scientific and commercial knowledge, combined with steady industry and prudent enterprise, are required to ensure success." Again, " A regard for economy and efficiency and durability should govern every step decided upon in the arrangement and construction of a mill, from the choice of site, through the erection, and down to the smallest detail of the mechanism."

THE MANAGEMENT OF COTTON MILLS.

The vast interests involved in the business of cotton spinning are of so important and far-reaching a nature as to make it imperative that the leading positions in cotton-spinning establishments should be filled by none but the best qualified persons; by men of sound common sense, proved ability and first-class character.

The management must be skilful, economical, and thoroughly honest, as the greatest care, good judgment and close attention are required in the management of spinning mills if they are to be successfully and profitably worked, in any country. The man who is wanted nowadays is the one who can produce a superior quality of yarn, and turn off a larger quantity in proportion to the extent of the machinery; a man who can work cheaply and economically, and who can keep the machinery in good working order, and manage the hands and the entire concern with credit to himself and to the satisfaction of his employers.

In view of the increasing keenness of competition, there is an absolute necessity to ever bear in mind the three prime factors of good management—quality, quantity, and economy. A technical knowledge of the work and detail of a cotton mill is absolutely necessary; also of the machinery and the manipulation of the cotton, etc. It will readily be admitted that the practical man who has from quite a lad been brought up to the business, and who has had a thorough insight and training in the working and management of such an establishment, possesses great advantages over those who have not been so favourably situated. No person, unless he devotes his whole energy in a thorough and intelligent manner to the business in all its important details, need ever hope to become a successful manager or prosperous cotton spinner. The only way to become a really first-class man in a cotton mill is to commence at the bottom of the ladder, and gradually work up. It is necessary to enter the mill when quite a young man, and work up right through each department, devoting a sufficient time to the mixing and scutching rooms, mixing, weighing and feeding; the same in the card room, on the cards, combers, and frames; grinding, stripping and setting, likewise in the spinning department, doffing, piecing and spinning. In one word, a young man learning the business should make himself useful in every department, and learn thoroughly how to tackle and work each and every machine in the mill. A certain period should also be spent in the machine shop, working at the bench and the lathe; and the fitting and erecting of the machinery should likewise form a special study and effort. The mechanism of the steam engine should also form a special and distinct study. By degrees a knowledge of cotton and yarn will be acquired; after which, close application to duty, coupled with energy and determination, will ensure success.

The foregoing is a brief outline of what it is necessary to go through in order to become a good practical mill-manager. Unless the manager is thoroughly and practically conversant with his business, he will of necessity be forced to leave much of the management of the different departments to the overseers, and they, holding minor positions, naturally feel less responsibility, much mismanagement and friction following as a natural consequence, entailing loss and annoyance to the proprietors and serious reflection on the manager, which must inevitably result in disgrace and failure. The manager who knows his business can not only give directions to those who are under him, but can discover whether or not they are qualified for the situation they occupy, and when they fail in their duty.

It is, therefore, self-evident that the only way to become a successful cotton mill manager, is for a young man to devote the whole of his energy and intelligence to the one object of becoming complete master of the entire business in every branch, down to the smallest detail. It is an utter fallacy to suppose that any man who has not been brought up in a mill can in a comparatively short time acquire sufficient knowledge and tact to enable him to take charge of a spinning mill. It is a matter of perfect impossibility for such to compete with the practical man who has been in the mill from boyhood, and has had every opportunity of learning the business thoroughly, both practically and theoretically.

The manager of a cotton mill, bearing in mind the responsibility of his position, must exercise a wise and conservative discretion in all his dealings, and bring to bear an intelligent conception of the various and multiplex duties he is called upon to perform; he should of necessity be well abreast of the times regarding the various processes and the improvements introduced from time to time in every branch of the business, and in the most improved manner of working the machinery; he must have a special knowledge of both cotton and yarn, and be familiar with the different calculations required in making changes, and in starting up a new mill.

To produce a good yarn, every department of the mill should be arranged and worked upon the newest and most scientific principles, and whilst every machine must be kept in the most perfect working order, all unnecessary expense, whether by alteration in the plan of the gearing or arrangement of the machinery, should be avoided, unless such alterations would improve the productive capabilities of the establishment, or unless they are absolutely necessary to suit local requirements. When once a mill has been filled, it is far better to let it remain so, unless the advantages that might accrue from alterations are very material.

The manager is daily called upon to consult with his principals on all manner of subjects relating to the conduct of the business; and in his opinion and advice he should hold first to the most generally accepted principles that have hitherto proved efficient and satisfactory, rather than fall in with new and untried theories of doubtful value; let his policy be guided and influenced by what common sense and experience dictate. It is important for the manager to know at all times the effect arising from any change in the qualities of the cotton, in the manner of preparing it, or any other alteration he may have occasion to make in any department of the process. In the manipulation of the cotton, so as to ensure regularity and even-running yarn of good and uniform quality, it is necessary to simplify and regulate to as uniform a degree as possible the laying out of the machinery and the grade and quality of cotton used.

It is impossible to lay too much stress upon the necessity of constant and continual—even daily and hourly—attention to the smallest details of the routine of the mill. Order, discipline, and a thorough and perfect system, are of the greatest importance; and very much may be gained by example supplementing precept, for this the hands are very quick in noting and unconsciously imitating, with greater excellence all round as the result.

The manager should endeavour to create a mutual good feeling and good understanding with the workpeople, avoiding, whenever possible, being too severe, but at the same time upholding his legitimate and proper authority; whilst being easy of access and affable in manner, he should conduct and carry himself with the dignity and firmness his position and responsibilities call for. He should not on any account allow the hands to be needlessly harassed, or unnecessarily interfered with, so long as they attend to their work in a proper manner. He should show no favouritism, but treat them as far as possible all alike, and according to their individual merits. Unless in extreme cases, fines should be avoided, as fining the hands is a most vicious, odious and dangerous practice; it leads to nothing but unpleasantness and ill-feeling, and results in no permanent good.

The operatives as a rule are, and naturally so, very unwilling to submit to fines. This deplorable practice of fining is unfortunately too much in vogue in some countries, but it is far better to turn the hands away altogether than to resort to this out-of-date mode of treatment. Unless in exceptional and peculiar cases, tact, judgment, and knowledge of the working-man and his ways should suffice to secure harmony and goodwill all round, for the workpeople, as a whole, have quite a fine sense of justice and equity.

Cotton spinning mills are very expensive concerns, requiring a large amount of capital to be invested in them for manufacturing purposes, and they must be very skilfully managed to insure success. Proprietors cannot be too particular in the choice of those to whom they confide the management of their establishments. Considering the great risk and the amount of interest at stake, this is all the more imperative, and the knowledge of it should serve as an incentive to all who wish to take a leading part in the management of cotton mills. The day has gone by for appointments to be made to the leading situations without consideration as to fitness and ability; merit is, as it should be, the only principle by which the appointment of an overlooker or manager can be decided. The whole mill may be fitted up with the best machinery, with all the latest improvements, etc., and everything may have been planned and arranged in the most judicious manner, but unless it is well managed, and the mode of government is sound and good, nothing will prevent a general collapse.

In bringing to a close these few remarks on this important subject, it may not be inappropriate to add that in this, as in all other things, every man must work out his own salvation. Let not, however, any young man be daunted. Close practical application and intelligent study will surely make him master of the intricate art of cotton spinning, in all its complex details, and he will become qualified to assume charge and control as manager of a cotton mill, with the bright and promising prospect of achieving the results above enumerated. Good men, men of brains, common sense and intelligence, are needed more to-day than ever, and for such there are better opportunities than ever in the history of cotton spinning. Be not therefore discouraged; learn self-reliance and confidence, and face the issue with a firm determination to be found at the front. Remember it is the young and unknown men of to-day who must to-morrow take the places of the old and tried men of yesterday. Let every young man make up his mind to be the coming man.

MACHINERY.

THE DIFFERENT MACHINES; THEIR DESCRIPTION AND USE.

In the following pages reference is made only to the machinery of Messrs. Dobson & Barlow, Ltd., of Bolton. It is hardly necessary to say that in a work of this kind, this is not done in order to advertise the machinery of the above-named eminent and world-renowned firm.

The descriptions, particulars, and calculations here given, and which have special reference to the manufacture of good quality yarns, have all been written and worked out by the author whilst engaged as manager of the Clark O.N.T. Thread Co., Newark, New Jersey, U.S.A. At these mills the whole of the machinery is made by Dobson & Barlow, Ltd.; and none but the highest grade yarns are spun.

We believe Dobson & Barlow's machinery to be eminently and conspicuously adapted for the production of superior yarns of all numbers, from the coarsest to the finest, whether for weaving, knitting, thread, or any other purposes.

The fact of the great American thread manufacturers above referred to, whose high reputation for excellent thread is so well known, adopting in their extensive establishment none but this particular make of machinery, is of itself a high testimonial as to its peculiar merits.

This work, moreover, is, as has been already stated, an epitome of the author's personal views and experience, hence in this matter of machinery, as well as in all other matters touched upon, no further explanation or apology is deemed necessary for the prominence that may be given to any department of the general subject.

OPENING AND CLEANING MACHINES.

Machines for opening, cleaning, scutching, and forming cotton into laps, to be fed up to the carding engines, have undergone very little change in design during the last few years, but changes have been made to economise labour by shortening operations, such as the use of single instead of double machines, and a better disposition and arrangement of machines in the mills.

BALE-BREAKERS.

The bale-breaker is of comparatively recent introduction into cotton mills, but it seems very likely, in conjunction with lattice arrangements for carrying cotton in the mixing and opening rooms, to become very general. In every country at the present time where cotton spinning is carried on, the cost of manipulation as regards labour becomes of more importance, and it may be fairly expected that it will become even more so.

The object of the bale-breaker is to imitate, as far as is practicable by machinery, the pulling asunder of the hard flakes of the bale as it is performed by hand. Cotton when packed green from the field by hydraulic machinery at enormous pressure, has the air driven out of it, and the fibres matted together by the pressure.

In old days when making the mixing, this cotton was all pulled asunder by hand. This was costly and ineffective, and the operation, as stated above, is now performed by mechanical process.

There are two descriptions of bale-breakers; one consists of coarse-toothed rollers in pairs top and bottom, with two, three, or four lines at increasing speeds, so that it may be said there is a draught between each pair of rollers; the other has one pair of top and bottom entering-rollers, followed by a roller with coarse teeth, working over weighted pedals underneath, and a pair of finishing top and bottom rollers with the requisite draught. In both cases the entering and delivery lattice running at the proper speed is provided.

It must be clearly understood that this machine is not intended to open the cotton, nor in the strict sense of the word to *draw* it in any way, but to break, as far as practicable, the slabs of raw cotton, and to permit of the air freely entering so as to temper and soften the fibre. Thus, after passing this machine, it may go to a lattice, which will carry it up to the ceiling lattices, whence it may be distributed over the mixing room in any direction as required. After lying in the mixing two or three days it will be found that the cotton which was originally hard and flaky, is soft and supple, and requires much less power and strain to open it for cleaning purposes.

In a mixing room provided with a bale-breaker and elevating lattice and distributing lattice, the cotton, by an arrangement of gearing, may be carried right or left, and for any distance required, thus permitting the bales as broken open to be deposited in any given quantity in any part of the mixing room. Where the mixing room is over the scutching room there are holes in the floor convenient to all the mixings, which, by the aid of tin shoots, allow the cotton to fall close to the feed-lattice of the opening machine.

In other cases, where the mixing room is on a level with the scutching room, or where it is desired to pass the cotton by tubes to cellular cleaning trunks, an exhaust opener is used, with a lattice running between the mixings in the mixing room, so that cotton can be fed on the lattice opposite the mixing, and conveyed to the porcupine cylinder, which after taking out some of the heavy dirt, sends the cotton to the tubes. This goes directly to the opening machine, and the feed of the lattice and the opening machine are connected in such a manner that when a lap is completed, the stoppage of the opener will also stop the feed of the porcupine. This carriage of the cotton by pneumatic action is not considered advisable by all spinners for the better classes of cotton, as it is considered to roll the cotton, and render it liable to damage in the scutchers and cards. There are no reliable experiments, so that it is still a moot point, but spinners who desire to economise the work without risking the quality of the production, have generally adopted the first-named system, and in this case the bale-breaker usually has pedals, the object being that in case of an extra hard flake of cotton going into the machine the pedals will cede rather than tear the fibre. It is extraordinary how, after the hardest lump of cotton has passed under these pedals without being apparently much affected, the tenacity and hardness of a lump in the course of a day or two is so reduced that it can be shaken to pieces in the hand. There can be no doubt that the bale-breaker and the accompanying lattices are of considerable economy and practical benefit.

The two illustrations Nos. 1 and 2 will give a clear idea of the details of these machines; the first one is the bale-breaker with four lines of rollers. As explained before, the two middle bottom rollers are replaced by weighted pedals for the finer cottons. The other illustration, No 3, shows the small porcupine opener with lattice feed as it is generally employed to feed single and double vertical openers, or vertical openers and scutchers combined. It is, of course, understood that the lattice in the second illustration may be made of any length to suit the arrangement of the mixing room.

OPENERS.

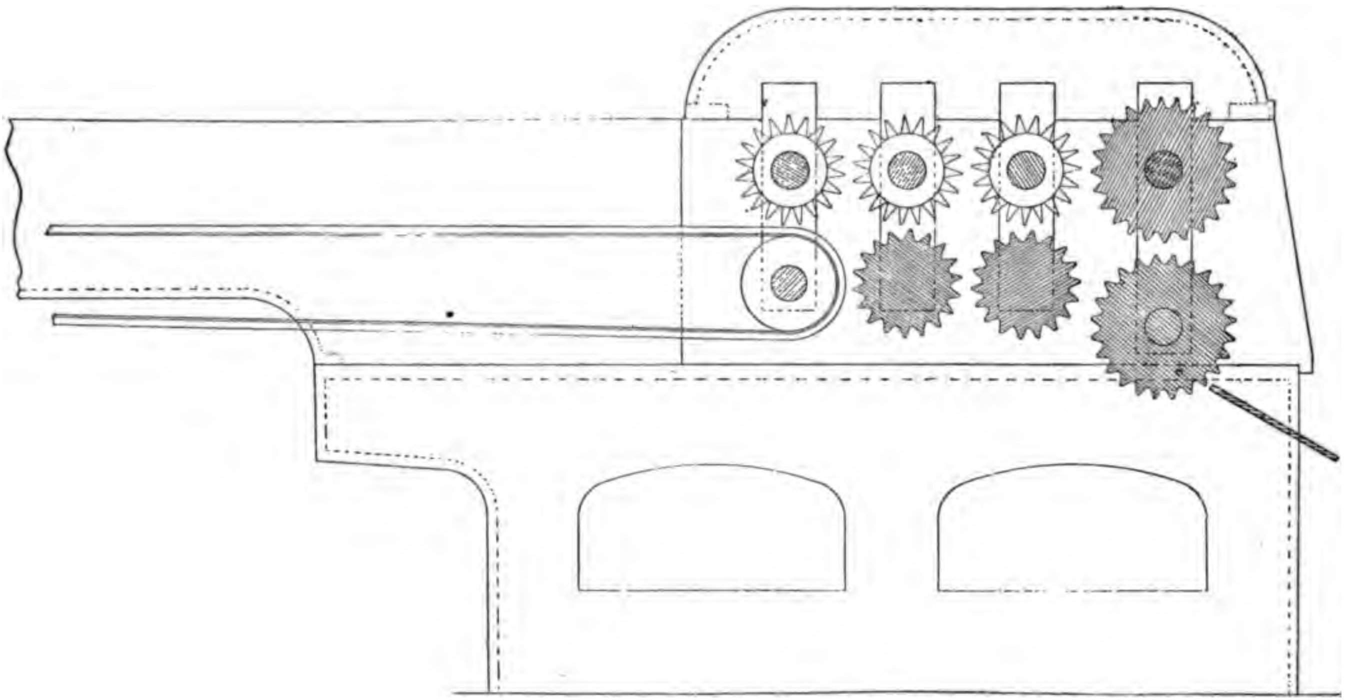
The subject of the proper class of opener for the finer Florida cottons, Sea Islands, Fiji, and in general of silky stapled cotton, has been a subject of great uncertainty, and it may be said to be still a question of comparative uncertainty. The delicacy of the filament or fibre is such that the less the amount of manipulation that can be applied to it the stronger and more silky will the resulting yarn be.

After much experience it has been found that the machine shown in the annexed illustration (No. 4) has answered better than any other for obtaining a regular lap without damaging the staple of the cotton. The machine has one opening beater and one finisher beater. The opening beater has six blades, in which hardened conical steel teeth are riveted, and the second has an ordinary finisher beater, but with three blades. The feed consists of two pairs of feed rollers and one pedal roller. There is a draught between the two pairs of feed rollers, which can be regulated, and is in fact so regulated as to assist in opening the cotton before it gets to the beater. Otherwise the machine is pretty much on a par in details with the ordinary double scutcher, but it is furnished with an extra sensitive pedal-regulating motion, in which the friction has been reduced as much as possible, and the motions are so strengthened that there is no flection. The result of this is that it is quite practical with ordinary hand feeding, without weighing, to arrive at a lap which is sufficiently regular from yard to yard to go direct to the carding engine. But this is seldom done, and it is preferred to do a little less work at the second beater, and to employ another single beater scutcher which will double four laps and by setting off the rollers in both cases, the cotton is not over-strained.

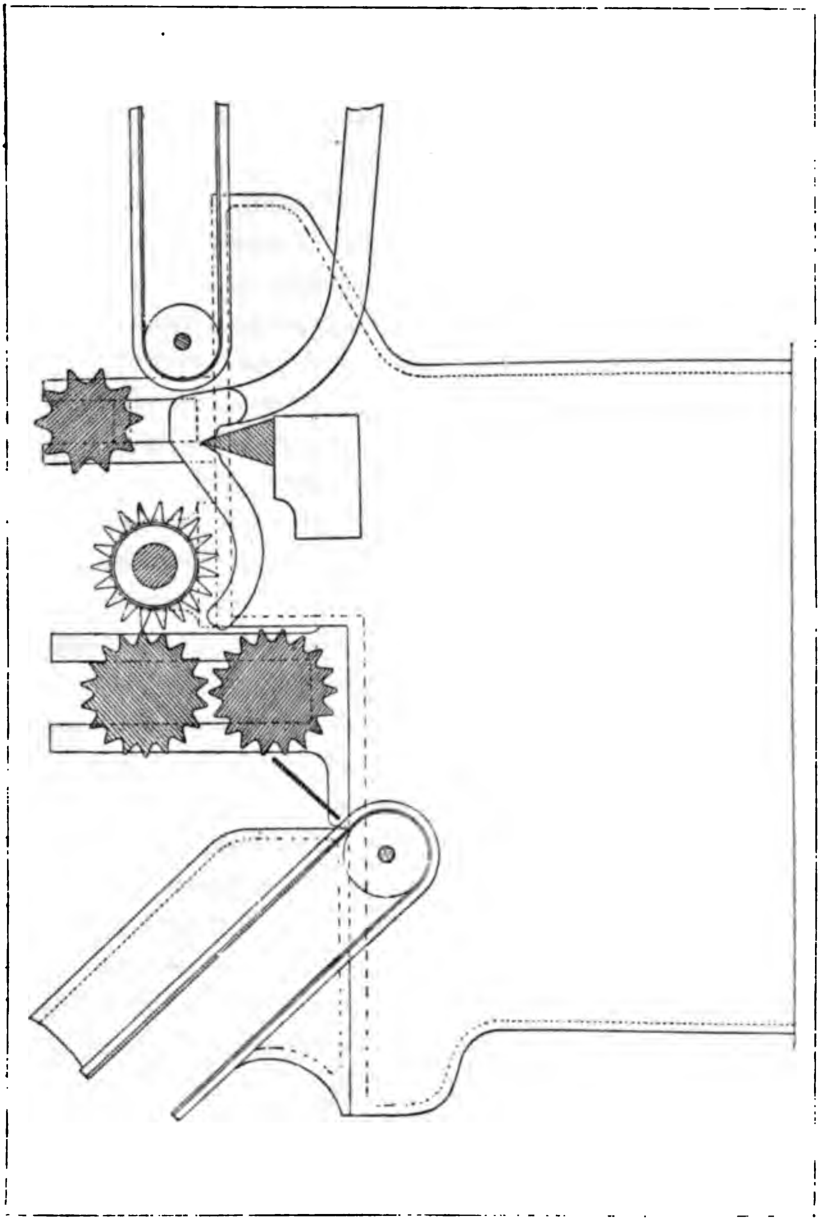
This of course is of vast importance when spinning fine numbers.

The single scutcher for doubling four laps is shown clearly in illustration No. 5.

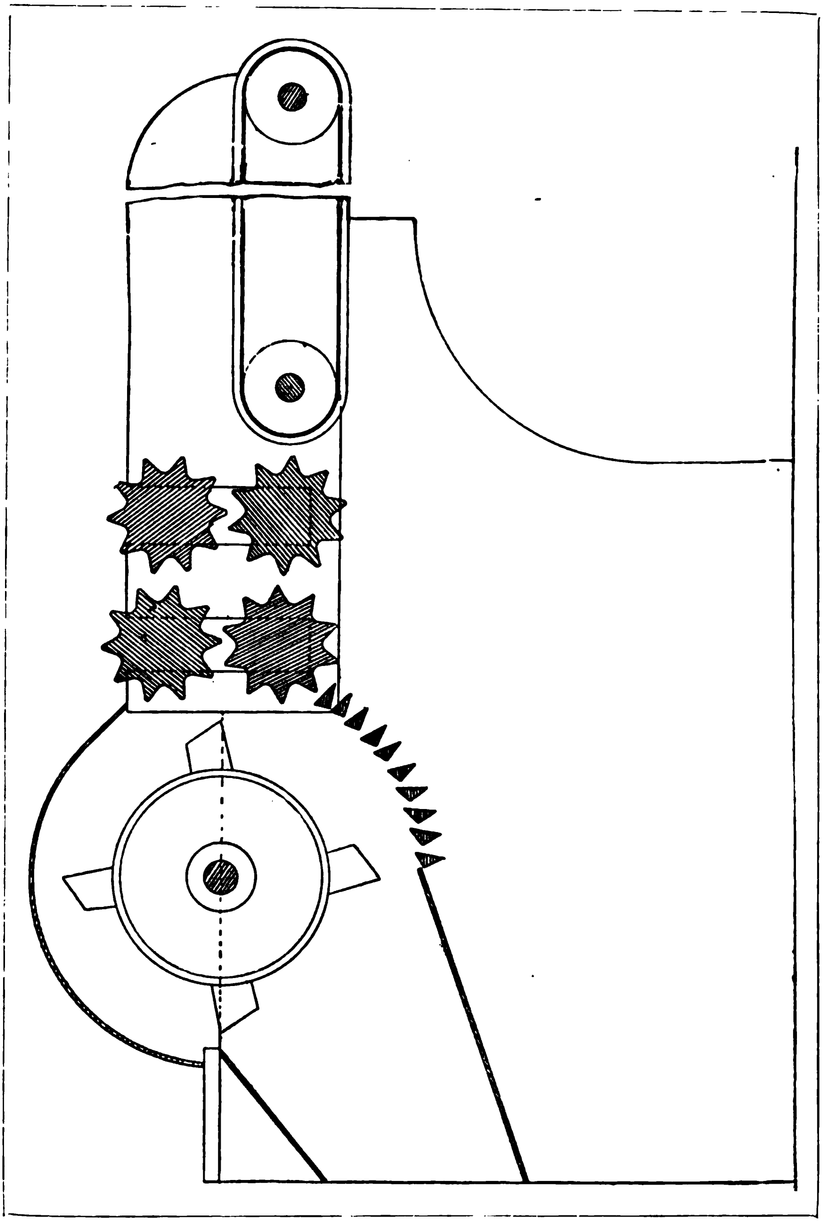
There are several other descriptions of openers; the principal of which are the Vertical Opener, the Porcupine Opener, the Compound or Combined Opener and Lap Machine. All these machines are so simple in



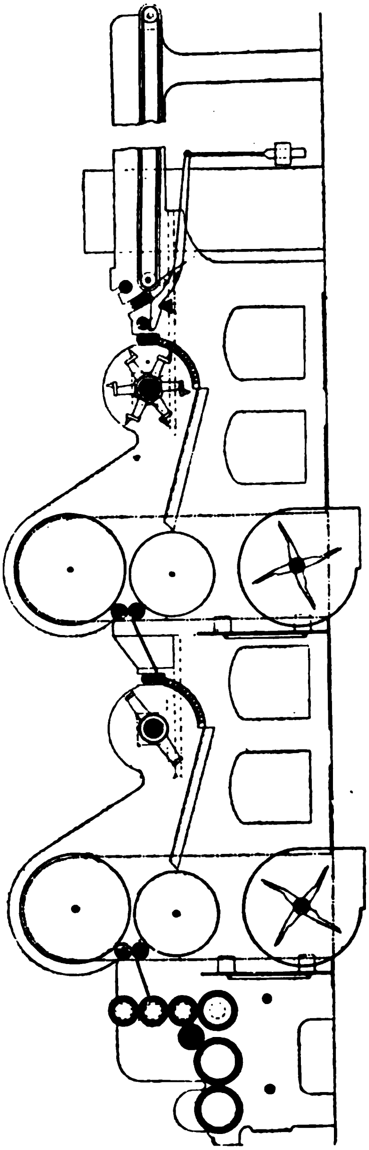
1.—BALE BREAKER WITH FOUR LINES OF ROLLERS.



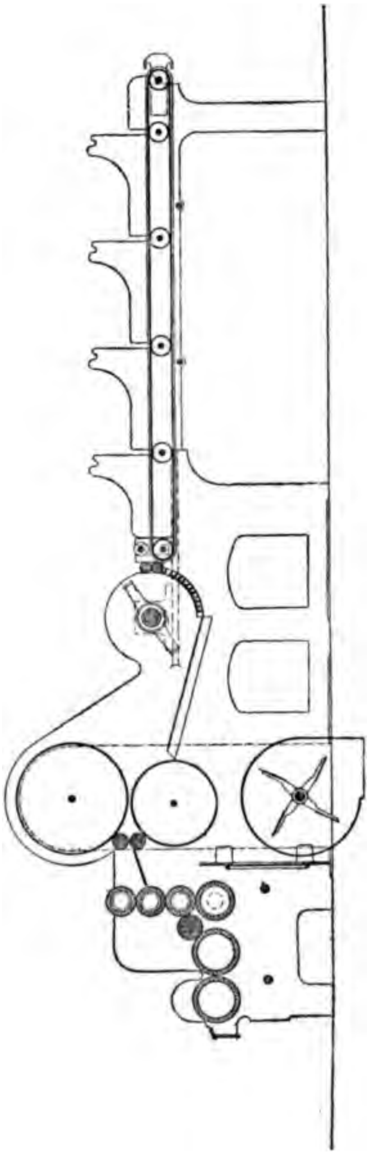
2.—BALE BREAKER WITH PEDALS.



No. 8.—PORCUPINE OPENER WITH LATTICE FEED.



No. 4.—DOUBLE SCUTCHER FOR FINE COTTONS.



No. 5.—SINGLE SCUTCHER FOR DOUBLING FOUR LAPS.

their construction and details, and their mode of working is so well-known, that no elaborate explanation of them is necessary.

The vertical opener is now very generally in use, in fact it has almost become universal, and it may be said to be almost indispensable in a cotton mill; especially where the cotton used is of a dirty nature. Its capabilities of thoroughly well opening up, and knocking the heavy dirt out of cotton are not equalled by any other opener. It is now made with a patent feed motion, which is a great improvement on the old system of feeding. The cotton is drawn into the machine, or delivered from the feed rollers of this apparatus, in a regular and uniform manner, so that the machine has a better chance than formerly of doing its work well and thoroughly. The cotton is far better opened and cleaned, and the staple or fibre is not damaged or "curled" as was formerly the case. The delivery is so regulated that the cotton is not damaged by being kept too long in the machine.

The Porcupine Opener is a first-class machine for opening clean American cotton, and is specially adapted for soft cottons; its action upon the cotton is less severe than the vertical opener, and the fibres are therefore less liable to be broken or damaged. The cotton is fed upon a travelling lattice, and after passing through the machine, and having been subjected to the action of the porcupine cylinder, it is delivered ready for the breaker scutcher in an undamaged state and beautifully opened. This machine altogether does its work well and efficiently. Its construction and the construction and working of the scutcher are on one and the same principle; the only difference being that in place of the beater in the scutcher, this opener is supplied with a porcupine cylinder. These machines are made with one or more cylinders. The speed of the porcupine must depend upon circumstances, such as the cleanliness of the cotton, and when the teeth get broken out or much worn the cylinder should be re-covered.

THE BREAKER SCUTCHER.

The cotton from the opener is weighed, previous to being put through this machine, after which it is spread upon the travelling lattice into a given length, breadth, and thickness, and this is called a feed; these feeds continually follow each other, so that a continuous web of cotton passes through the machine, and is rolled on to a roller until it is of sufficient size, when the machine knocks off, and the cotton, which is now called a breaker scutcher lap, is taken and put on the finisher scutcher. The breaker scutcher further opens up the cotton, and likewise knocks out the sand, seeds, and heavy dirt; to allow of these matters being got thoroughly rid of, the bars or knives at the back of the beater should be set pretty well open and at an nice angle. The dust box should be let down and cleaned or cleared of all dust, fly, &c., about every two hours. The weighing and feeding at this machine should be well and accurately done, and the tenters should be carefully watched to see that they do their duty properly, otherwise they get very careless, and it is then impossible to keep the laps regular. It is very essential to have good drafts in the scutching.

THE FINISHER SCUTCHER.

The laps from the breaker scutcher (say 3 to 4, according to local circumstances) are now put on to the travelling lattice at the finisher scutcher; the cotton is again broken up at this machine, and likewise passes through in a continuous web, and once more rolls itself upon an iron roller into what is called a finisher scutcher lap, or breaker card lap. The finisher scutcher likewise beats out what sand, seeds, or dead cotton still remain in the cotton, or may have escaped the action of the breaker scutcher beater. This machine also helps to disentangle the fibres, and spreads them out, so that when the cotton enters the card, it is so separated that the card teeth can take hold of the fibres separately. The beater blades must be set to the feed rollers, according to the staple of the cotton; the bars at the back of the beater may be set closer than in the breaker scutcher, as there is less dirt here to be got rid of. Under any circumstances the setting of the bars must depend upon the cleanliness or otherwise of the cotton. The dust box should also be let down and cleared of all fly, &c., about every two hours; and the flues, as in the breaker scutcher, regularly and thoroughly swept.

There is generally a patent feed motion attached to these machines to regulate the weight of the laps; the great necessity of keeping the laps regular and as near one weight as possible cannot be too earnestly impressed upon the reader, for upon this point depends the regularity of the yarn. The doubling also tends very greatly towards regularity.

Scutchers have undergone considerable modification within the last few years, and the general practice now is to scutch cotton less than was formerly the case.

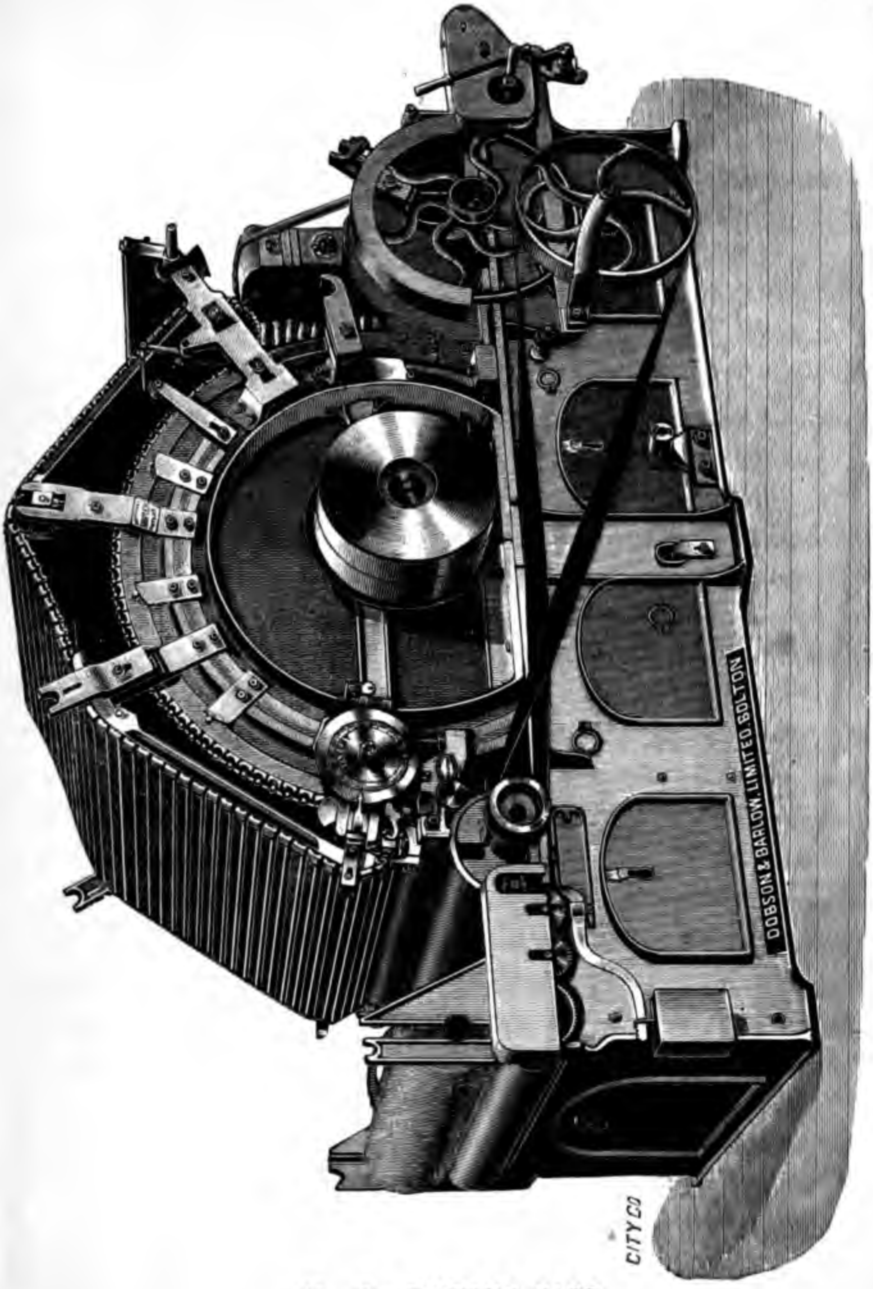
In modern mills a dust cellar is usually made under the blowing room, into which all the fans blow, and from this a dust flue or chimney is taken to the highest part of the buildings—the higher the better; the area inside depending upon the number of the fans. Free and ample outlet is of the utmost importance.

Air space in dust pipes should not be less than one and a half square feet for each fan, and outlets from dust rooms not less than three square feet for each fan.

All turns in dust pipes should have an easy or circular sweep; sharp and abrupt corners should be avoided. The dust pipes should be round instead of square.

THE CARDING ENGINE.

For coarse, medium, and fine counts the self-stripping revolving flat card is now almost universally used. Some spinners, however, still prefer two sets of cards, *i.e.*, for the breaker, rollers, and clearers, and for the finishers revolving flats; but the combing machine is now very generally taking the place of the finisher carding engine, and this machine is indispensable when a clear, strong, and uniform thread is required, as it completely separates the long fibres from the short ones, which the carding engine does only partially.



No. 6.—SIMPLEX CARD,

The carding engine is the most important machine in a cotton mill; it is, as it were, the backbone of good spinning. The wire of the carding machine should be kept clean, the points sharp, and set as close as possible to each other without touching.

The carded cotton should be quite clear and free from all dirt, motes, or dead cotton. This can only be attained by having a thorough system kept up of grinding, stripping, and setting. The most approved system is light and quick carding, so that the engine is not overloaded, nor the wire surcharged. The card has then a better chance of doing its work, and the fibres are not weakened by being kept too long in the card.

The less cotton is carded the better, so that the dirt is taken out and the fibres are laid straight; after this the cotton by being continued in the cards is only weakened. The great object of the carding is to draw out the fibres from one another, to straighten, clear, and lay them side by side, to separate the long staples from the short, and to form them into a thread, commonly called an end or sliver. As the laps run out they should be neatly pieced up to one another, and the cans should not be allowed to get choked up or be pressed too hard.

Good carding is essentially necessary, as it forms the base of good cotton spinning; and as it is utterly impossible to make anything like a nice yarn unless the grinding, stripping, and setting be attended to regularly and systematically, the very greatest care and attention should be devoted to this most important department.

The number of times it is necessary to strip each day, or the number of times it is needful to grind each card, must of course depend upon circumstances, such as the quality of the cotton used, and the hours worked. It is the card-master's especial duty to look after these matters, but the manager should have an independent and regular system of going through the cards himself.

The following chapter on "The Theory of Carding" is by permission here reproduced from Mr. B. A. Dobson's work on "The Principles of Cotton Carding, etc.

"THEORY OF CARDING.

"Now for the theory of carding. I do not know whether any of my readers have ever tried the effect of running a carding engine at a very slow speed, say for instance, instead of running the cylinder 160 to 180 revolutions per minute, turning it at 20 or 30; but if any one has done this he will have found that there was practically a very slight difference in the quality of the carding. This may be noticed every day in any cotton-spinning mill when cards are stopped by the strap being thrown on the loose pully. If the cards are properly constructed they can be stopped and started without any great apparent difference in the "web" or in the cotton coming off, sufficient to show when the difference of speed was made. This would seem difficult to understand if it were not for an examination of the surface or circumferential speeds of the various portions of the machine. For instance, in the example of a revolving flat carding engine, carding Egyptian cotton at about 8 pounds per hour, the feed roller being 1, the licker-in would be 1,733, the cylinder 3,608, the doffer 132. Now the cotton coming over the surface of the dish-feed, and being worked by the licker-in, the projecting ends are straightened to a very considerable extent, as may be seen any time by stopping the feed and pulling the lap back for examination.

"When I say "if the cards are properly constructed," I refer to the method of casing-up these portions of the circumferences of the cylinder and doffer that are not actually engaged in working the cotton itself: as, for instance, over the end of the chain of flats to the junction of the doffer and cylinder, and from that junction to the front of the doffer above and below, and from the junction of the cylinder and doffer underneath the cylinder to the licker-in, and, further in the same way, from the licker-in to the beginning of the chain of flats. These portions of the machine are, it is evident, of almost as great importance for producing regular work as the setting of the working organs; if there is any space that ought not to exist, it will become filled with fly.

"The fly is prevented from falling upon the working surfaces by the action of the draught of air caused by the revolution of the cylinder or doffer; but when the revolution is stopped, and with it the draught, the fly at once falls down and engages with the wire on the working parts and shows itself, when the card is re-started, in a white streak along the width of the web. This is sometimes sufficient to break down the end, owing to its forming a lump too thick to pass through the funnel. Too much care cannot be exercised in the arrangement of these silent organs of the carding engine, and no ingenuity will be too great to provide for their easy and exact regulation. It is in some measure owing to the care given to these particular parts of the engine that carding sufficiently regular to supply single carding yarn of 60's can be allowed to replace what used to be made in double carded yarn 120's; in fact, I might cite several other cases where the improvement of carding has added to economy of manufacture.

"As I said before, with proper construction of the card it may be started or stopped without any mark on the web to show that the continuity of action has been broken.

It will be found that the lap, if tolerably regular itself, has the ends combed out and tapered from the full thickness of the lap to the thickness of a few fibres, and appears almost clean in that portion which has already been operated upon by the licker-in. As the cotton is fed forward by the feed roller, the points of the licker-in teeth seize hold of those fibres that are sufficiently liberated and carry them round past the dirt knives and the undercasing to the point of contact of the cylinder and licker-in. In this passage much good work may be done: nearly all leaf can be extracted and dead cotton shaken out, and this with little or no fatigue to the staple and a minimum of loss of good fibre. In some continental countries practical managers consider this of so much importance that by preference they personally do the setting of the knives and undercasings. I have no doubt that these knives and undercasings, constructed and regulated improperly, will account for dirty carding and excessive waste. The angles of the knives and bars in the undercasings, the distance from one to another, and the distance between the points of the licker-in teeth and the knives and bars, are of great importance, and need adjusting to the requirements of the staple of the cotton being used.

Although there are as many points of wire on the surface of the licker-in passing any given point at any moment as there are fibres of cotton to be worked at that particular point, it will be readily understood that it is not possible for each point to take its particular fibre of cotton. This can be practically seen by examining the conditions of the tufts of cotton which come off the licker-in when the undercasing is removed. These tufts consist of aggregations of an undetermined number of fibres, the numbers being determined by varying conditions of the setting, the number of points, the shape of the points of the licker-in teeth, the quality of the opening of the cotton in the lap, and, lastly, the speed of the licker-in. This being so, and these tufts being carried round to the point of contact with the cylinder, we can understand that, as the cylinder has a surface speed more than twice that of the licker-in, and as the number of points of wire passing in a certain time is as 27 to 1, these fibres, presented in tufts, will not be taken away in the same condition, but will be taken to a certain degree one after the other. They are presented in a dishevelled condition to the action of the cylinder wire; and each fibre, being tolerably free to part from its companions, being seized by one of the points of the cylinder wire will go away freely and thereby equalise on the surface of the cylinder the number of fibres in a given space. For instance, the number of points of cylinder card wire passing a given point in the circumference in one minute will be somewhere about 362,000,000, and the points of the licker-in passing any point of the circumference are about 13,750,000 per minute, and the number of fibres fed in one minute 13,750,000. Now it will be evident that the cotton coming from the feed-part, having been taken away by the licker-in and presented to the cylinder, being taken in detail as far as practicable by the latter, will be to some extent stretched and parallelised, and this simply owing to the difference of circumferential speed together with the difference of the number of points of teeth of the two organs. It will thus be fairly equally distributed on the working surface, and will be found to have lost a certain amount of its heavy dirt and leaf; but it is still curled and twisted, and the short cotton or fibre is still with it, and there is also the "nep" that may have been produced in the gin, the opener, intermediate, and lap machine.

Now comes in the action of cleaning, the organs for which, as before explained, may be rollers and clearers, or flats. As the cylinder in passing from the licker-in to the doffer has to carry its cotton past these cleaning organs, these flats or other organs will seize the superabundant fibres and retain them for a certain time, if there should be any irregularity in the aggregations of the cotton fibres, this time depending upon the length of the fibre. The long fibres are naturally held more securely by the flats than the short fibres,—in fact, when once very short fibres have been presented to the flats the cylinder is incapable of taking them back again. This is one of the most valuable effects which render possible the cleaning of cotton in the card. This condition is dependent upon the wire of the cylinder and flats both being in proper order. The further equalising process, and one which tends to parallelise the fibres coming from the card, is the giving of the cotton by the cylinder to the doffer. Now, as you are aware, the doffer is clothed with wire finer than the cylinder. Where the cylinder is 130 to the inch the doffer will be 140, the object of this difference being to give the doffer more points to seize the fibres presented by the cylinder; and it will be further seen that—on the same principle of difference of circumferential speed, but reversed, by which the cylinder and licker-in have equalised the numbers of fibres in a given surface by exceeding the speed of the feed organ—the doffer, by running slower than the cylinder, further increases this equalisation, by, as it may be said, condensing the areas of variation. This particular operation is practically the same as the doubling in the succeeding processes. The doffer on receiving the cotton on its surface from the cylinder, and turning at, say, a surface speed of 132 to the feed roller one, is, by reason of the knife of the undercasing, which is passed as far between the cylinder and doffer as possible, cut off from any further interference by the cylinder, and presents its cotton to the doffing comb without any further change. This particular action of a carding engine is often spoken of by old card overlookers as the best carding point of the machine; and upon the accuracy of the surface of the doffer wire, the closeness of the setting to the cylinder, and the state of the teeth of the doffer wire, depend the equality and smoothness of the web taken off by the comb. The taking of the web through the condenser plate and calendar rollers or draw-box to the coiler is absolutely identical in all cards, and requires no explanation. I give on the following page a table showing the particulars of the figures from which I have quoted. This table is taken from a paper I read before the Bolton Mill Managers' Technical Association in April, 1886.

"It may further assist if I state that in taking the ordinary Egyptian cotton as carded in a Bolton mill for No. 60's, the weight of lap per yard is 10 ounces, the speeds of the various organs are as per the following table, the waste to the licker-in is 2 per cent., the waste of the cylinder is one-half per cent., and that on the flats $3\frac{1}{2}$ per cent. The compressed thickness of the lap may be taken as about the forty-seventh part of an inch; and the thickness of the layer of cotton, if there were such a thing as a layer, on the various organs of the card would be: On licker-in $\frac{1}{81471}$ inch; on cylinder $\frac{1}{169573}$ inch; on doffer $\frac{1}{6204}$ inch. The thickness of fibre of ordinary Egyptian cotton is the $\frac{1}{1526}$ part of an inch, which will show that the cotton on the working part of the card is not a continuous web, film, or layer, as you too often hear it talked about when carding is being discussed, but consists of fibres and aggregations of fibres with relatively large spaces. The extent of space of the working surface compared with the surface of cotton, is, for the licker-in as 23·5 to 1; for the cylinder as 50·8 to 1; and for the

Carding Engine Working Egyptian Cotton.—Single Carding for 60's Twist.

NAME OF WORKING PART.	Revolutions per Minute.	Diameter in Inches.	Circumferential Speed in Inches.	Proportionate Speed.	Nos. of Wire Clothing.	No. of Points of Wire on 1 In. x 40 Inches.	Area of Working Part in Sq. Ins.	No. of Points on Working Parts.	No. of Points at Work.	No. of Fibres on Working Parts.	Fibres on 1 In. x 40 Inches.	Waste per Cent.
Feed Roller	1	2¼	7·068	1	—	—	—	—	—	—	1950066	0·6
Licker in	400	9¾	12252	1733	8	1120	680	34305·6	19040	18819	1107	1·6
Cylinder	160	50¾	25504	3608	120	24000	3760	3825600	2256000	49791	529·7	·41
Doffer...	12	24¾	933	132	130	29000	1760	2254750	1276000	605176	13754	—
110 Revolving Flats...	—	—	3·75	0·53	130	29000	1760	3190000	1276000	—	—	3·3
8 Stationary Flats ...	—	—	—	—	100	21000	400	210000	210000	—	—	3·0
8 ,, ,,	—	—	—	—	110	23000	400	230000	230000			
8 ,, ,,	—	—	—	—	120	27040	400	270400	270400			
8 ,, ,,	—	—	—	—	140	28000	400	280000	280000			
Doffing Comb	1137	8¼	29472 6	4208	—	—	45	660	660	—	—	—

doffer as 1·86 to 1. It will be seen, therefore, that the licker-in has a few more points of wire than there are fibres on it at any time. The cylinder has at least four times as many points of wire as there are fibres, and the doffer over twice as many, and in 110 revolving flats, of which 44 are constantly at work, there are eight times as many points of wire as there are fibres of good cotton on them.

"From the foregoing remarks it will be seen that some of the existing ideas regarding the action of carding must necessarily have been founded on a want of knowledge of the actual conditions, and that no doubt much misconception has arisen owing to the belief that there was always a large amount of cotton between the cylinder and the flats or rollers actually under operation.

"The effect of centrifugal force on carding (as an assistant power) has also been very much exaggerated. No doubt centrifugal force does aid to a certain extent, but not to anything like the degree generally attributed to it. This can be proved, as I have said before, by reducing the speed to an absurdly slow rate and observing the work. The fact is that centrifugal force has been confused with the action of the air upon the cotton. To thoroughly clean and parallelise the fibres it is necessary that the cotton should not remain in one position whilst under the operation of the cylinder and flats. One result of the speed is that air is taken in and carried round by the cylinder, and when meeting with the bevelled flat this air is to a certain extent compressed; at any rate its density is increased when the cylinder has carried it under the heel of the flat. When past the heel the air will naturally escape into the space between the flats, and in the action of expanding and escaping will raise the fibre from the wire of the cylinder. This naturally brings up the question of what is really the action of the card wire upon the cotton. This point has caused so much contention that it has been with some diffidence that I have ventured to include it within the scope of my remarks; but having been forced by circumstances to discuss this question with many individuals, I have to a certain degree formed conclusions thereon.

"It may be said that in carding, as in most other things, there are two extremes, and between these will range the gradations. In the first place there is quality, and in the second place quantity. If quality alone be wanted, irrespective of the question of production, the same conditions do not hold good. The same remark applies exactly in regard to quantity. I maintain that it is impossible to get at the same time the maximum of quality and the maximum of quantity, but that as one increases the other suffers. In fact, this is an axiom or principle that is universally applicable, not only to carding but to almost everything else. It is, then, more a matter for the spinner to decide as to whether the result is satisfactory to him or not; if he prefers quantity it is an easy matter to arrange to have it, and *vice versa.*"

CARDING ENGINES.

Perhaps there is no machine employed in the manufacture of cotton which has received so much and such careful attention from machine makers and spinners as the carding engine, particularly the revolving flat carding engine. Especially is this so of late years. The production in both quantity and quality have been increased enormously, and it is now possible to get a better result with single carding than it used to be some twenty years ago with the double carding. This is due to more careful construction, to improved card wire, and above all to the employment of the dish feed and the licker-in covered with saw-tooth wire. The two latter applications have given a degree of certainty in controlling the work done in the cotton that surpasses anything previously discovered.

The further improvements in revolving flat carding engines I may enumerate as follows:—

1. Simplicity and certainty in setting the whole of the flats.
2. A thoroughly certain and easily controlled method of maintaining concentricity between the cylinder and the flats.
3. Utilisation of the total width of the cylinder for the purpose of carding.
4. Absolutely perfect selvages.
5. The absence of loose fly in the internal organs of the machine.
6. Facilities for grinding and stripping.

7. Completeness, simplicity, and facility for setting all covers and knives.

8. As short a flat as possible compared with the width of the lap.

9. Oiling arrangements so perfected that no damage can be done to the wire.

10. Increased facility for testing of setting.

11. The greater accuracy of construction, generally combined with strength and solidity, thereby avoiding vibration.

The above points are those that require the most careful consideration. A practical defect in the revolving flat card was, that owing to the method of grinding the flat in its reversed position, the natural deflection of the flat prevents the centre from being ground as much as the outer ends. But on the other hand, when the flat is turned over to work to the cylinder, the deflection takes place in the contrary direction, so that the flat must be set to the centre, and the ends will be as much farther off the cylinder wire than the centre, as twice the deflection when grinding. This deflection has been found to vary from the 80th part of an inch to the 200th part of an inch. Seldom less than this. This would mean that if the centre of the flat is set the 200th part of an inch from the cylinder wire, the end of the flat will be nearly a 50th part of an inch, and of course the carding in these parts will not be as well done as where the wire is closer.

As I have said, this defect exists in every carding engine where the flat is ground with the wire upwards. Attempts have been made to overcome this by various devices, such as levers, pressing a part of the flat upward to overcome the deflection, but of course, this is mere guess-work, as the flats will vary in tenacity and strength from one to the other.

The question of grinding from the working surface and the correctness of the flats, has, of course, nothing to do with this question, which is simply one of deflection.

One device for overcoming this objection is that used on the "Centenary" card or "Centenary Simplex" made by Messrs. Dobson and Barlow, of Bolton. In this the flat is turned over on its axis about the centre of its course, over the cylinder, and ground in its working position from the working surface. When the grinding is completed the flat is turned over again into its normal position. Thus every flat must be ground in the same way, and consequently set the same distance from the cylinder wire both as regards the relation of one flat to its neighbours, and also as regards the distance of the points of the wire across the whole width of the card.

So far as can be seen, this improved grinding and the consequent improvement in setting must allow a considerably larger production than the ordinary card, whilst retaining the same quality or a better quality of work with the same production.

The author has had exceptional opportunities of studying and putting to practical test this "Centenary Card," and is, therefore, in a position to testify to its capabilities, which have proved to be most excellent. The carding of Egyptian or American cotton, is in comparison with that of Floridas or Sea Islands, comparatively easy, as all who have had any varied experience in carding well know, and we are glad to be able to state that the results from this card are most beautiful and perfect—and with the Sea Islands varieties. Some of the finest and best yarns that are being spun in America to-day, are being carded on the above named machine.—Let us give credit where credit is due.

For further information on the subject of deflection of flats the reader is referred to a work on carding cotton by Mr. B. A. Dobson published by G. S. Heaton, Bolton, in which this subject is treated at considerable length.

This article ought not to be concluded without reference being made to the enormous strides made in the manufacture of card wire, whereby a certainty is made of that exactness which is so necessary to produce good work. It is in this that the principal difficulty of this manufacture has consisted.

CARDS AND CARD CLOTHING.

Of late years the revolving flat card has come very largely into favour for the medium and coarse counts, as well as for the finer qualities of yarns, and the machinists and card clothing manufacturers have devoted much time and attention to the perfection of the details of this machine and its clothing. The marked advance in the increased production and superior quality of the carding obtained, as also the more economical working of the revolving flat card, is in a great measure due to the introduction of hardened and tempered steel wire, which is much stronger, harder, and consequently more durable than the mild steel or iron wire previously in use, which has now been almost entirely superseded by this hardened steel wire. Following the introduction of hardened and tempered steel wire, various processes have been patented for the purpose of producing what is known as a needle, or fine point, on the card tooth. The system most in favour is that known as the patent plough ground; this process of grinding is very effective, and reduces in the most perfect manner the thickness of the card tooth from the point to the bend. By the use of this process the card maker is enabled to use a thicker, and consequently a stronger wire, and thus to get strength at the bottom of the tooth, just where strength is most required, whilst by cutting away the top part of the tooth a very fine point, so essential to good carding, is ensured as long as the card lasts, as the tooth from its point down to the knee or bend is reduced several sizes in thickness, and the metal so cut away gives more space or clearance between the teeth. This side ground wire on its first introduction was left rough, or striated, on the sides of the tooth by the emery discs used in grinding, and, on this account, made little progress for a time for the finer qualities of yarns; but this objection has now been entirely done away with by a system of polishing the wires after grinding. The largest makers of these hardened and tempered needle pointed cards, Messrs. Sykes Brothers, Huddersfield, have invented a system of polishing after grinding, which leaves the finished card all that can be desired in that important respect—smoothness. Speaking from a very considerable experience of the working of these polished needle-pointed, hardened, and tempered steel cards, the author has been able to produce a stronger, cleaner, and more silky yarn than it was possible to do from the ordinary wire previously in use, as cards so made, having finer points and being stronger, can be set closer and require little grinding. Hardened and tempered steel plough-ground wire should be ground lightly and with fine emery at the mill. From three to six times per year, depending on the cotton used, will be found sufficient for cylinders and doffers, whilst the flats will not require grinding more than once per year if properly set and burnished occasionally. It is best to grind cylinders and doffers with the Horsfall or traverse emery wheel grinder, and the flats with a good true long roller. No. 40's emery is the size recommended by the best makers for grinding hardened and tempered steel card clothing. The extra clearance obtained by plough grinding enables this card to be run a longer time without stripping, but it will be found advisable to strip cylinders and doffers at least twice per day with a circular brush made of fine steel wire for that purpose.

The card clothing on arrival at the mill should, of course, be unpacked to see that it has not suffered in transit, and the fillets before being used should be opened out of the paper covers and carefully unwound into a skip, and placed for a few days in a warm room about the temperature of the card room.

Before clothing see that the iron cylinders and doffers are perfectly clean, and that the wood pegs do not protrude or stand up above the level of the cylinder or doffer; in case they do, they must be pared or levelled down.

The card fillets should be put on tightly with an even strain throughout, and great care should be taken to have the tail ends also put on tight. The cylinder and doffer fillets should be wound on to the bare polished surfaces of the cylinders and doffers. No paint or any other material should be used. Care should be taken to have all the teeth well rubbed up at the back during the operation of wrapping on. Be careful in tacking to avoid putting any tacks at the extreme edge of a fillet, as this often leads to breakage. It is necessary to put on the grinding-rollers after clothing, in order to insure a perfectly level surface. If the long roller covered with emery is used, be careful to see that it is true and in good condition; grind lightly until you are quite sure you have obtained a perfectly level surface, after which finish up with the Horsfall. Very much depends upon getting a very level card to start with, and on no account should this be neglected, as very little future grinding will then be required, and the card can be set very close without actual contact.

After a new card is started, for the first two or three weeks be careful to see that the cylinder is stripped out perfectly clean to the bottom three or four times a day. As soon as the cylinder is found to strip freely and clean, less stripping will suffice. If the brush fillet is applied for a few minutes each week to cylinder and doffer, very little grinding will be necessary.

SLIVER LAP MACHINE.

This machine is known in the trade as a Cheese machine, a Derby Doubler, or a Sliver Lap Machine. For making laps for double carding it is generally called a Derby doubler, but for making small laps for combers it is invariably termed a sliver lap; in either case there has been little or no alteration in the machine since it was first designed, except that it has been simplified; and the chief improvement has been the application of the loose end-plates to the lap spindle. As the side pressure of the cotton is very considerable, the stationary plates formerly used spoiled a considerable percentage of the cotton through rubbing and burning by friction. In some of the continental mills these machines are arranged *à bascule*, and as soon as one lap is completed the machine lifts away the full lap, and puts down another spindle for a fresh lap. This, however, is an unnecessary complication, as a knocking-off motion to stop the machine when the correct length has been wound on the lap is quite sufficient for all practical purposes, and the longer I live the better I am persuaded that simplicity must be sought in machines more and more, if the cost of labour is to be kept within reasonable bounds.

RIBBON LAP MACHINE.

This machine, the prototype of which was originally made in Alsace but which has been much improved in England, and of which there are a very large number working in the United States, is a machine which, although secondary in its position, is of primary importance for economical and regular combing. Before the invention and adoption of this machine it was customary to pass the slivers coming from the carding engine through one head of drawing before proceeding to the sliver lap machine just described. This renders the fibres parallel to a certain extent, and to that extent aids the work of the comber by preparing the sliver to admit of the needles passing through the cotton with the least resistance, but it will be readily understood that as the slivers were presented to the spoons of the stop motion at the back of the sliver lap machine in the shape of a round sliver, and that 13 or 14 of these were placed side by side, there must be a considerable difference of thickness between one portion of the lap and another immediately contiguous. This is very easily proved by taking any lap made in this way, and holding it up to the light, when the thick and thin places formed by the ribbons or ropes of sliver will be readily apparent. Considering the exact character of the setting of a combing machine, and the delicacy and thinness of the fibres of cotton, it is evident that this imperfection must be a serious one in some respects, and it was and is so now in the waste made, as between the thick portions of the lap, in the width, some of the long fibres in the thin parts cannot be held so securely as others, in which case those not so held are very liable to be carried away in waste. The ribbon lap machine obviates to a singular degree this imperfection. In it a certain number of laps, generally six, made on the sliver lap machine with the unavoidable irregularities and imperfections, are placed on the feed-creel behind the machine. From this each lap is passed through four lines of drawing-rollers exactly the same as the ordinary draw-frame. In these four rollers there is a draft of about six. When the sliver comes out of the front rollers, instead of being passed through a funnel or trumpet and made into a round sliver, it is passed round a curved plate and let down to a horizontal plate in the front, and the six flat ribbons are superposed. They then pass through a series of calendar rollers which consolidate the lap and prevent its licking or sticking, or becoming 'furry' in the creel of the comber. The difference in the regularity of the thickness of the lap made on this machine and on any other is readily noticed, as I said, by holding it up to the light. In the one made in the ordinary way there will be streaks showing the position of the round slivers from the draw-frame, and in the other it will be equally coloured all across, and no signs of variation in thickness can be seen. Now with regard to the practical value of this machine in the mill, I say it is of an advantage because as it replaces a drawing-frame there is no extra machine, but, on the other hand, the regularity of the laps presented to the comber is much greater, and the exactness with which the lap can be held by the nipper of the comber is such that I do not think I exaggerate in stating that there is an advantage of a clear 1½ per cent. in the waste; that is, with the same class of cotton worked on the two systems I have described, I can get 1½ per cent. less waste with this ribbon lap machine. In these days of competition it will be generally conceded that this is a matter of great importance. I may mention that this system of drawing slivers flat instead of round, for the purpose of having equal drawing, has been carried to considerable extent in some of the older-fashioned fine spinning mills, where the only time in which the sliver was made round after the process of drawing was in the last head before the slubber, and there can be little doubt that except for the trouble and labour and the amount of room taken up by the ribbon boxes, this system had certain distinct advantages.

COMBING MACHINE.

Perhaps there is no machine known in the cotton trade that has varied less in detail from the first one constructed up to the present than the Heilman Combing Machine. There are other machines than the Heilmann, such as the "Hübner" and other circular combers, which I will not describe at length, as there are, to my knowledge, none at all working except in certain districts on the Continent. In England and America I may say there is not even a solitary one.

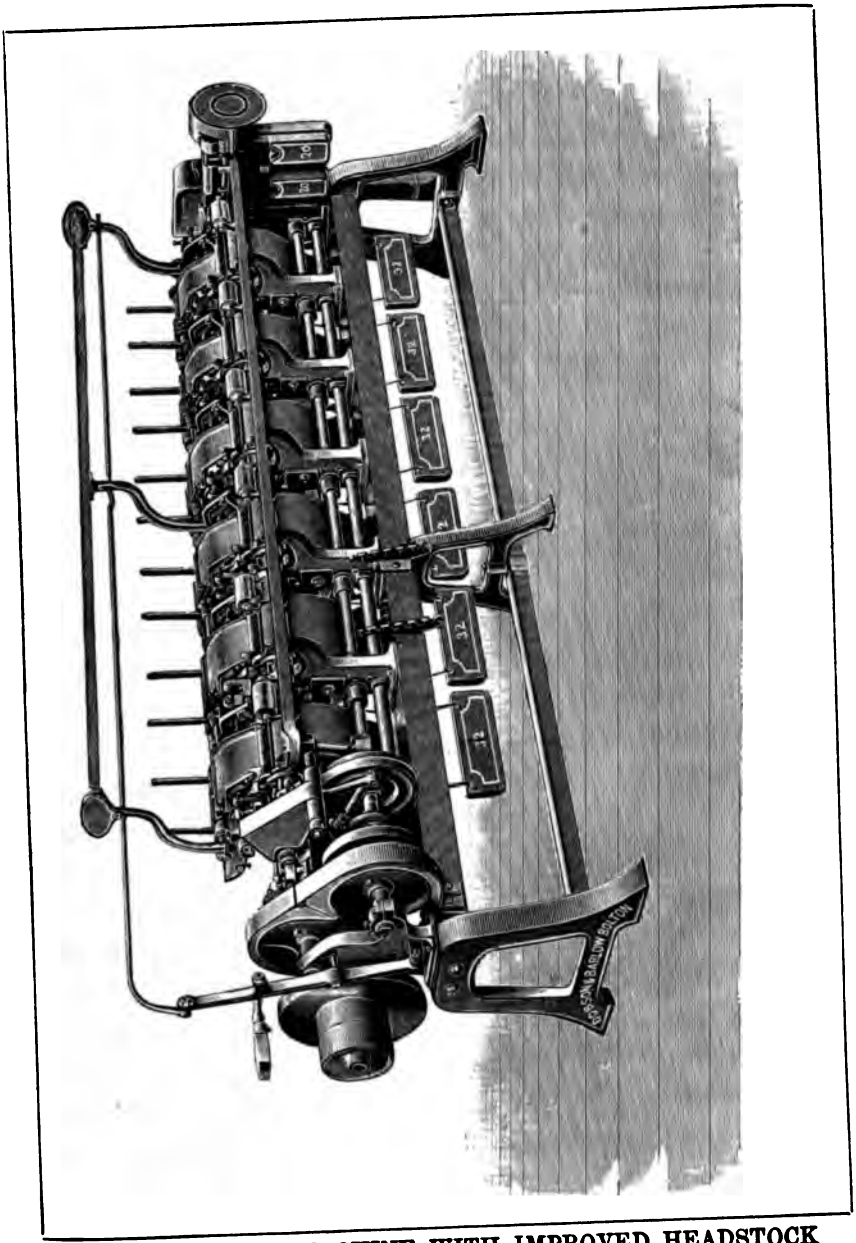
The idea of the circular Comber was to construct a machine capable of producing considerably more than an intermittent machine such as the Heilmann, and so far as the question of production is concerned, it must be admitted that this was achieved; but the circular machine depended in a great measure upon leather bands to carry the cotton before and after combing, and in certain climates it became so charged with electricity as to absolutely prevent its working with any degree of regularity. In any climate the circular comber for cotton may be said to be a barometer and thermometer combined, and the slightest change in temperature or in the density of the air is at once evident in its working.

The Heilmann comber is free from many of these defects, and although it, like other machines in a mill, is always subject to the vagaries of electricity, it is perhaps more under control than would be supposed. All the same, there are some instances that are very difficult of explanation. For example—and this fact the writer can certify—it is possible to comb, with the same width of roller, 1-in. wider lap in England than in America, and this difference proceeds absolutely and entirely from the fact that the rarer or drier air of America allows the action of repulsion of electricity to act on the fibres to such an extent that at least 1-in. more margin of roller is requisite. This is no conjecture or theorising, but an absolute fact which it has cost much time and trouble to ascertain. I presume the general characteristics of the comber are familiar to most of my readers, but for those who may not be so conversant with the matter, I may mention that in all cotton there is a variation in the length of the fibre which is roughly denominated long and short, and that each of these two divisions may be further subdivided, and that the long will include the fibre from the longest down to that which is termed short, and the short will contain all the less valuable fibre and the impurities. The object of the combing machine is to extract all the impurities and shorter fibres, so as to present for the subsequent spinning operations, a cleaner, more regular, and consequently stronger material.

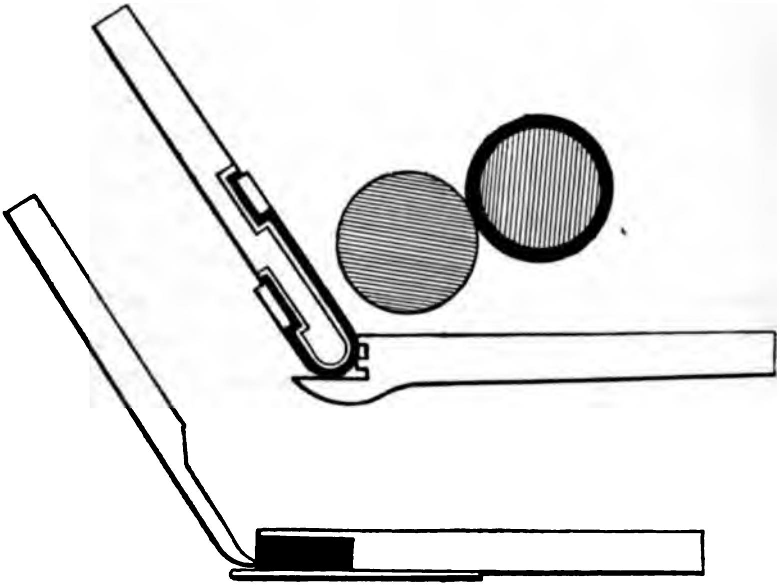
It is said that the idea of his beautiful machine was suggested to Josué Heilmann, the inventor of the comber, by seeing one of his daughters combing her hair. I must say that, further than seeing the comb pass through the cotton and the cotton held by the nippers, I can see no further similitude, because the hair is attached firmly to the head, and the cotton is loose at both ends; and further, both ends require combing. The lap furnished by the sliver lap machine, or the ribbon lap, as described in the previous chapter, is placed in the feeding-creel behind the comber, and passing under both feed rollers top and bottom, or between a porcupine roller and a feed plate, is fed to what is termed a nipper. This nipper consists of articulated upper and lower jaws, one of which forms a pressing edge, and the other being covered with leather makes a cushion for this edge. As soon as the nipper is open and the cotton is fed through by the feed roller both nippers are lowered round the centre, so as to bring them in juxtaposition to the periphery of a circular comb, which consists of 15 or 17 rows of graduated needle bars, from coarse to fine, the coarsest being 20 to the inch, and the finest 85 to the inch. It will be evident that all fibres and other material not held by the nipper will be removed by the passage of these combs. As soon as the combs have passed there comes a surface on the same centre and about the same periphery as the circular combs, of what is termed "fluted segment," and upon this, while revolving at the same surface speed, is lowered into contact what is termed a "detaching roller" covered with leather, which, being weighted, seizes the fibres left by the circular comb, and draws them away from the nipper, which is now opened; but in tho meantime the top comb has been lowered and has passed through a portion of the clean combed cotton between the end of the laps and the roller. This top comb is made of needles 63 to the inch, and by its position and fineness prevents any short fibre or impurities from passing through. The short fibres and impurities, generally termed waste, are left at the extreme end of the lap previously combed, and are removed on the next passage of the circular combs. This action is intermittent but repeated, and the ends of the combed cotton are joined on to the ends furnished by the next revolution of the machine, and by an ingenious reversing arrangement of the rollers termed piecing, come out in the front of the machine in the shape of a round sliver.

This rough description of this beautiful machine I have considered necessary, as there are many of my colleagues who have had experience in single and double carding who have never had the opportunity of examining a comber; especially in foreign countries is this so. Combers were originally made with four heads or deliveries, this was subsequently increased to six, and some years after English machine makers took hold of the machine the comber was generally strengthened and made with eight deliveries, and the position in mill economics of this machine is perhaps more important now than at any other time. It has been found necessary to strengthen the diameter of the shafts and to divide the torsion by placing the actuating cams in the centre, so as to drive right and left; also by making what used to be iron shafts, of steel, and all this with a view of obtaining greater speed from the machine. When the comber first came to Manchester I believe that 54 strokes a minute was considered reasonable. Shortly afterwards it was found that 60 could be reasonably achieved, and this remained the speed for many years. It was only when the machine became of more general use, and the numbers of combed yarn were lowered down to good qualities of 30's and so on, that the production of the machine became seriously a matter of economy. Then the speed was increased, and by alteration of the reversing mechanism, and the adoption of positive distances, backward and forward motion, the speed was greatly increased, and it is now no uncommon thing to find combers running 86 revolutions.

I began this paper by stating that no machine had been less altered than the combing machine since its invention, and indeed the only alterations of importance that I can mention beyond the general construction of the machine, are the improved nipper and the improved headstock gearing, made by Messrs. Dobson & Barlow, of Bolton, of which machine I give an illustration (No. 7.) The nipper might be considered a very simple improvement, but it is of great importance, on account of the extra facility that it gives for setting. The old nipper(No. 8)used to be formed by the two plates forming



No. 7.—COMBING MACHINE WITH IMPROVED HEADSTOCK GEARING.



No. 8.

No. 9.

Nos. 8 and 9.—OLD AND IMPROVED NIPPERS.

the jaws, one of which was furnished with two ridges in the direction of its length, and a third ridge higher than these two. The other plate was rounded at the end, and over this was passed a piece of roller-leather held in its place by clips. It then became necessary to set these three ridges so that two of them might press directly on the leather, and the third and lower one against it. This was a difficulty of importance, and the consequence of any inexactness was increased waste and irregular work, and it also required a very skilled mechanic to set the nippers accurately, and even then they were very subject to derangement. The improved nipper (No. 9) also consists of the two plates forming the jaws, but the one that had the three ridges on is now represented by a plate having a hollow slot planed in it, which is filled with a piece of ordinary leather, having a flat upper surface. The other jaw is finished so as to present an edge or nose to the leather. As this nose can fit across any portion of the width of the leather, and can adjust itself to a certain degree horizontally to the surface of the leather, it is evident that there will be a continuous contact, and consequent nip of the cotton that cannot always be secured by the more complicated and rigid form before described.

I understand Messrs. Dobson and Barlow are still further improving the comber, having adopted the invention of Messrs. Bourcart, of Guebwiller, the town where the comber was invented and first made. This comber is stated to work at 120 nips per minute, with a considerably less speed of comb through the cotton, and is stated to be most successful. I have not had the opportunity of testing this for myself, but I think it useful to mention it, as there is a tendency to increase the quality of yarn by combing, and any machine that increases the production and consequent economy of this operation must be of interest to all cotton spinning countries in the world.

COMBERS.

One comber of six heads will produce in 55 hours 300 lbs. when working American for 30's to 40's.

Do. Egyptian, 60's to 80's, 250 lbs.

Do. Sea Islands, 80's to 100's, about 200 lbs.

Do. Sea Islands, 100's to 200's, about 150 lbs.

Weight of laps for American 12 dwts. per yard.

Do. Egyptian, 9 to 10 dwts. per yard.

Do. Sea Islands, 6 to 7½ dwts. per yard; 14 ends up at the lap machine for the above laps.

SPEEDS.

American, 90 to 100 revolutions per minute; Egptian, 80 to 90; Sea Islands, 70 to 85.

Curling may be caused by the detaching roller being badly covered, short of oil, touching segment out of time, or by fluted top detaching roller being badly set.

TAKING PER CENT.

Add weight of waste and cotton together, and then multiply the weight of waste and cotton, thus :—

Cotton	58 grains.	15
Waste	15 „	100
	73	73) 1500
		20½ per cent.

The weight of sliver produced in the comber is an open question, and is regulated by feed and weight of lap as in carding engine, according to requirements.

The waste made in the comber is from 10 to 25 per cent; American, 10 to 15; Egyptian, 10 to 15; Sea Island, 15 to 25.

	EGYPTIAN.	AMERICAN.
Feed rollers move at	4½ to 5*	*6¼ to 4¼
Detaching roller moves forward at	*6 — 6⅛	*6⅞ — 5¾
Do. top do. touches segment at	6 — 7¼*	*6¾ — 6½
Top comb down	*5½ — 6¼	not lifting 4
Nipper closes at	8¾ — 9¼*	*10¼ — 8½
Clutch wheel in gear at	*¾ — 1½	*¾ — ½
	Those marked (°) are very good times.	The times marked (°) are for very good quality.

NOTE.—The following all make more waste, viz:

The greater the angle of combs,

The later the nipper closes.

Late feeding.

Close setting. For instance, setting top comb close to segment and nippers close to cylinder combs, means close setting.

Erecting and Setting Combers.

Send all top rollers to be covered, and scour fluted rollers and segments, put machine in its place and level it.

Setting Cylinders.

Put in the cylinders, and set the index wheel to 5, with gauge $1\frac{1}{8}$ between flutes of detaching roller and front edge of segment. Make the cylinder fast to the shaft, and then set the detaching roller flutes to 23's gauge from flutes on segment.

Setting Nippers.

Put on the cushion-plates, and set them up to the thickness of a sheet of writing paper from the nipper knife, and to gauge $1\frac{3}{16}$ inch from flutes of detaching roller to front edge of cushion-plate; the nipper must be open and the stop-screws about $\frac{1}{4}$ inch through; next set the edge of the knife to 19's or 21's gauge from cylinder needles, with the right-hand screws only, and see that the distance between detaching-roller and cushion-plate has not altered (a $\frac{3}{8}$ inch gauge must be between the point of top screws and nipper stand) then set the left-hand screws by removing the gauge, and letting point of screw touch the stand, then put on the springs; move the cam till the bowl is on the circular part, and gauge $\frac{3}{8}$ inch again between stop-screw and stand; then screw up the nuts on one connecting-rod till the gauge is just eased. Now turn the cam till the screw points are eased from stands, turn the cam back again as it was, and try your gauge between the knife and cylinder (combs) and see that all are quite clear and to gauge.

Setting Feed Rollers.

With gauge $1\frac{13}{16}$ inch between flutes of feed and detaching rollers, make them fast, put on the top rollers and springs, and set the roller parallel to bottom rollers, and a convenient distance from the nipper knife.

Setting Brushes.

Let the bristles touch the brass of the combs of one cylinder, then make a gauge to go between the brush and cylinder-shafts, and set the others to it.

Brush Tins.

Set them about $\frac{1}{8}$ inch clear of the cylinders and doffer, and $\frac{1}{2}$ inch clear of the doffer where the tin and doffer meet.

Lap Plates

should be set clear of wood and feed rollers, and clearer brushes must touch feed roller.

Lap Guides

should be set $\frac{1}{4}$ inch wider than laps, and central with box of feed roller.

TOP DETACHING ROLLERS.

Move the 80's wheel on cam shaft out of gear, and turn round the cam shaft till the quadrant moves forward, then set the index wheel to 6⅛, put the 80's wheel in gear, turn round and see that the roller moves forward at 6⅛, then clean, oil and put on the brass tubes (on rollers), then put the rollers in and weight them, rest on the segments and bring up the lifters till the nearest will admit one thickness of paper between it and the tubes (the bowl must be on the highest part of the cam); move the small slides on the lifters till each will admit one thickness of paper like the first, and set them so that the rollers will touch segment at 6¾.

FLUTED TOP DETACHING ROLLERS

should be set with the greatest care so that the flutes be parallel in the flutes of bottom roller, and quite clear from leather roller.

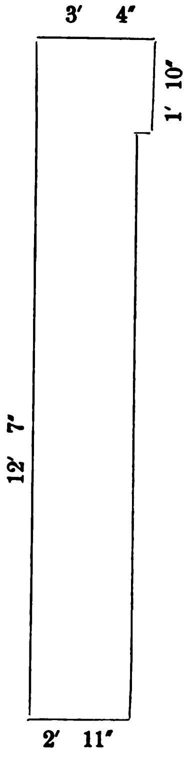
TOP COMBS.

Set these to 19's gauge from segment of cylinder, and to 14's angle of top comb gauge, put on the sliver plate and gear up all the draw box, coiler and wood rollers, set the doffer combs and gear up the doffer shaft.

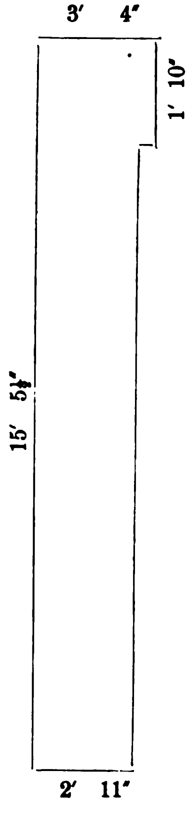
NOTE.—Be sure that all screws, etc., are well screwed up and all bearings are well oiled, and the cams well greased, and mind that the combs do not get damaged (the above is for cotton 1⅛ to 1½ inch staple.)

For American Cotton $\frac{7}{8}$ inch staple, the distance between flutes of feed and detaching rollers is $1\frac{1}{8}$ inches, and from flutes of detaching roller to front edge of cushion plate 1 inch, and from segment to detaching roller $\frac{7}{8}$ inch.

Space Required
for a Comber
of 6 Heads.



Space Required
for a Comber
of 8 Heads.



THE DRAWING FRAME.

At the drawing frame a number of ends, say six or eight, are put up together, and then doubled and drawn through the rollers, in order to equalise the sliver, and to straighten and lay the fibres parallel and in a longitudinal direction. Upon a proper arrangement of the drawing and doubling the particular quality of the yarn in a great measure depends. By passing the cotton between two pairs of rollers, and making the front ones revolve faster than the back ones, it may be drawn to any extent required; therefore the effect produced by the relative motion of the rollers is called the draft. When there is a sufficiency of doubling at the most suitable departments of the process, and when the fibres are well straightened and drawn, the yarn will be more level and even, as well as stronger and smoother. The drawing sliver should be delivered from the front roller as clear and level as a board, and the drafts should be nicely and equally arranged.

The rollers and flats should be kept clean, and the leather rollers should be well and accurately covered and kept in good working condition. The saddles and weights should be accurate, and both front and back stop-motions should be in perfect working order. The sliver is generally passed through three heads of drawing, and in changing, the change ought to be made between the first and second rollers, as the greatest amount of elongation takes place here.

The gearing for connecting the four lines of bottom rollers should be at the driving end of the frame. By this arrangement each roller starts simultaneously, thus securing a more equal drawing of the sliver, and also doing away with cut places when the frame is started after a broken sliver has been pieced. The front and back rollers are connected by a crown wheel arrangement; and the second and third rollers are connected with the back roller by separate and distinct carriers, either of which may be altered without affecting the speed of the other roller. The wheels and pinions are of much larger diameter than formerly, by which means a finer variation in the weight of the sliver is secured. When the draft is altered no difference is made in the intermediate drafts, and the operation of changing is altogether simpler than in the old plan with the connection at both ends. The bottom rollers are case-hardened, and are therefore better able to resist the severe strain put upon them.

The gearing has a much stronger and better support than formerly, thus producing a better quality of work, through the drawing operations being made smoother and easier. The front stop motions are most sensitive and quick in action, thereby preventing much waste, and producing far better work. The back stop motions likewise act with great precision when an end or sliver breaks, stopping the frame before the broken end reaches the back roller, and thus enabling the tenter to piece the end before it has disappeared between the rollers. The arrangement which causes the front and back stop-motions to stop the frame is called the knocking-off motion, and is very simple and easy in its action, needing very slight force to make it act; it acts rapidly, and is not liable to derangement.

A can stop-motion is now in use for stopping the machine when the front or receiving can is full. It is a great advantage to put the same length of sliver into each can, so that all will run out at the same time, when put up to the second or third heads, or at the slubbing frame. The tenters then know which cans require replacing without looking into more than one can. When the quantities in the can vary, they have continually to look after them, or the frames will stop very often. Another great advantage of the can stop-motion is that it prevents the cans from being choked up, thus the sliver is not damaged, nor are the coiler tops broken, as in the old system. The work of the tenter is more systematic, and a greater weight is got through the drawing frame, with at the same time a slower speed of the front roller.

These machines, while following the progress made of late years, have been subjected to no change whatever as regards the principle of their action, in fact it might be said at once that in no department of cotton spinning has there been any variation from the most ancient known methods of preparing and spinning; all improvements made have been in the details of the various organs of different machines, and have really been a progress of construction.

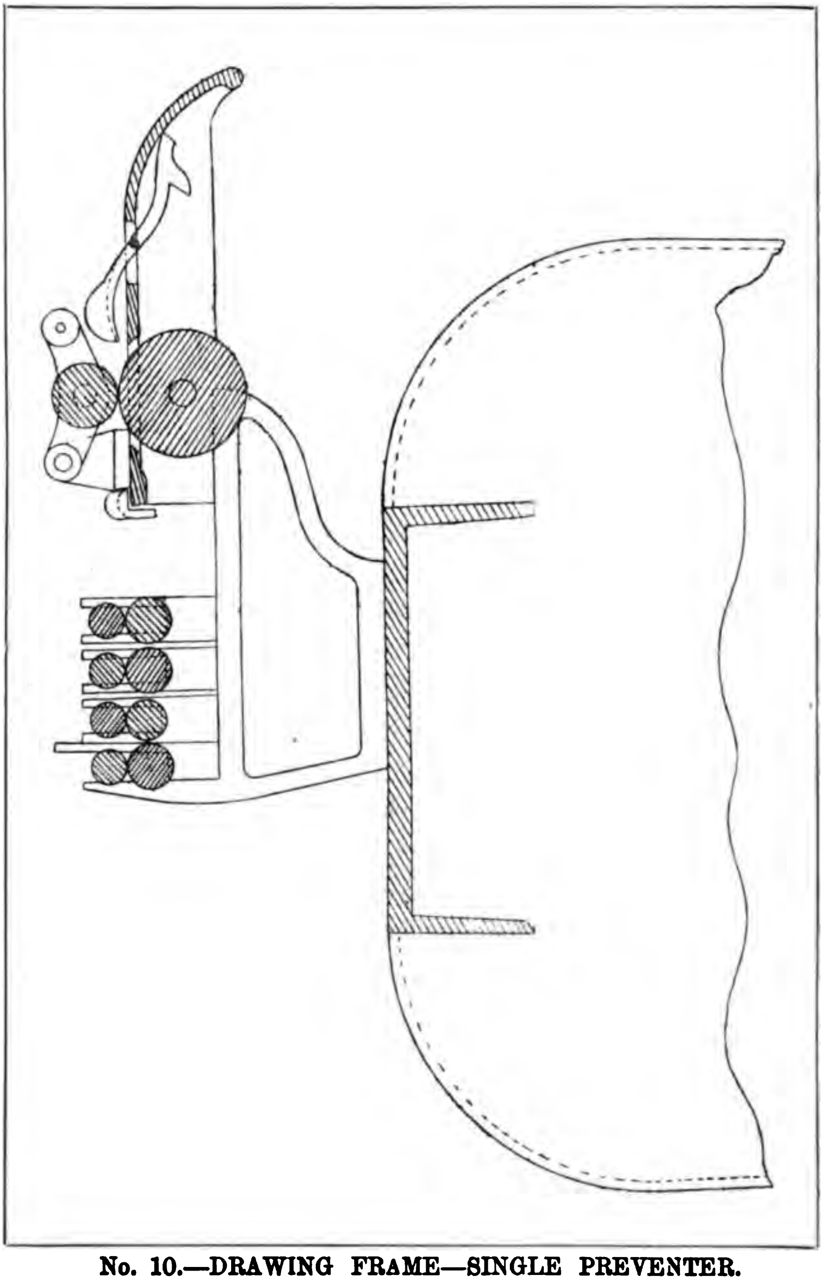
Thus, the drawing frame, although absolutely alike in its essential principle, is a different looking machine to that in vogue some 30 years ago. The framing and the principal portions of its construction are more massive and solid, and this enables a greater speed to be run without vibration. For fine numbers the question of the fluting of the bottom rollers is of greatest importance, as also the finish of both top and bottom rollers, and all the polished part of the machine over which the cotton has to pass. Combed cotton especially is ever subject to electrical disturbance, and it is astonishing how an invisible defect in metal will show in the mill with combed cotton in dry cold weather, or in east wind. In double-combed cotton this is so marked that the cotton appears as if alive, rising and falling in the air without any apparent cause.

In examining matters in detail, I refer first to a distinct improvement in a pair of extra rollers behind the drawing rollers and close to the stop-motion. This organ acts a three-fold part. It tends to draw the cotton from the cans without there being so much strain upon it, and consequently so much risk of breakage. It allows a greater pressure to be placed upon the stop-motion spoons, and thereby enables them to work quicker and to be more certain in action; it also, by a slight draught between itself and the first line of bottom rollers, aids the drawing by the slight preparation it gives. This motion can be clearly seen in the annexed illustration No. 10. With it no breakage of sliver can take place between the first line of drawing rollers and the extra rollers, and, consequently, no "single" can ever pass into the drawing rollers. The top roller is pivoted, so that to piece a broken end it is not necessary to over-lap the ends of the slivers, but the top roller can be lifted up, the broken ends joined, and the whole goes forward without any thick part in the sliver.

Probably one subject that has occasioned cotton spinners more uneasiness and difficulty than any other in the drawing frame is the question of the top clearer, the fibres being entirely without twist, and as parallel as it is possible to get them, and in a loose condition, are, as I have said before, very subject to electrical disturbance, and one result of this is that the ragged or staring fibres instead of proceeding with the bulk are often taken up by the top roller, and tend to form a layer on the roller. This, of course, if allowed, would be fatal to good drawing, and therefore comes the application of what is known as top clearers, these being generally a piece of stationary flannel pressing with a certain weight on the top rollers.

By its friction, the flannel removes the fibres which otherwise would remain on the roller, thus spoiling the drawing, and causing the rollers to still further lick. But in getting rid of one evil another is created, and, perhaps, one only second in importance to the first, if not more serious. That is, the fibres that have been taken by the flannel are rubbed and rolled into lumps, which are known as flat waste, and unless the top clearer is constantly and very thoroughly cleaned, lumps continue to drop on the sliver that is passing underneath, are taken forward, and make uneven and dirty yarn. How to avoid this has, as I have said before, been a problem to spinners for many years.

To describe the variety of clearers that have been devised for cleaning drawing-frame top rollers would



No. 10.—DRAWING FRAME—SINGLE PREVENTER.

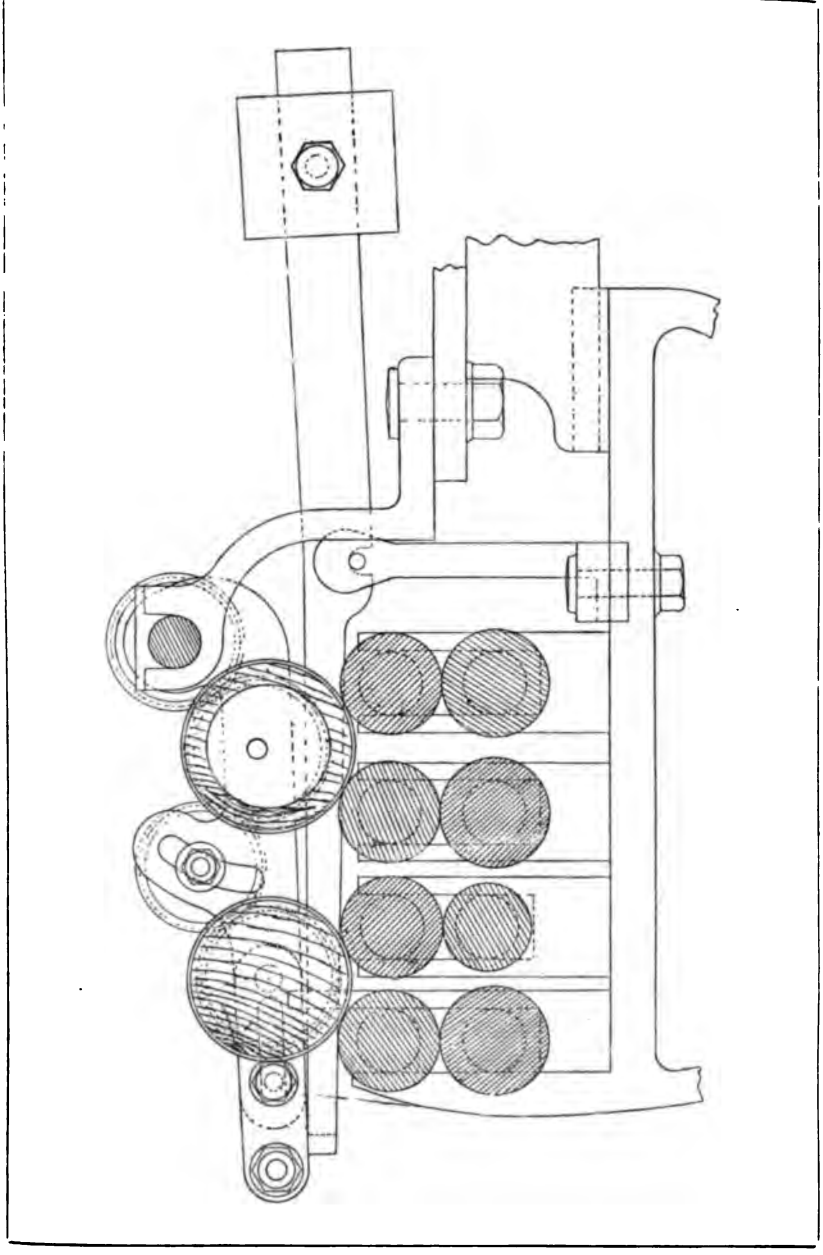
require more space than can be allotted to the subject in this work; but I may say that stationary cloth lying on the top rollers; revolving cloths driven by weighted rollers inside a continuous band of flannel; weighted rollers covered with flannel between the first and second and the third and fourth rollers; rollers driven by friction and by gearing; a tightly stretched band of flannel driven positively, and the waste combed off by positive driven doffing combs—all these have been tested and found in some degree wanting.

It is requisite, if a clearer is to clear the roller, that the flannel should move either faster or slower than the roller it has to clean. It is obvious, if the speed were the same, there would be no friction, no rubbing, and consequently the fibres would not be removed; and further, if they were removed, they would have the objection of the stationary clearer by allowing the loose fibres to be rubbed into lumps. The object should be to produce what is termed "felting," and this can only be done by obtaining a proper speed and maintaining it.

Again, if the roller that works with the flannel be too much weighted, or not sufficiently weighted, it will be objectionable, and the work will be deteriorated. If, for instance, the weight is sufficient to drive a heavy top-clearer by friction alone, there will be a slight drag on the motion of the roller, injuring the drawing, and this will cause an increase of the licking and of waste fibre which it is the intention of the clearer itself to obviate. This difficulty has been got over with the finer cottons—Egyptian and Sea Islands class—by what is termed the "balanced clearer," in which a positive driven roller for the front and second line, and a loose hollow light roller for the third and fourth line, perform the operation of clearing the draw-frame rollers; and having at each side a weighted lever with a movable and adjustable weight, they allow the exact amount of pressure to be given to the clearer, which is necessary to remove the adherent fibres from the top rollers.

This, I can say from practical experience, is the most perfect motion ever yet invented. The clearer requiries cleaning once a week only, whereas in the old stationary clearer it was necessary to clean it every two hours. In no case can one single fibre get back from the clearer to the rollers and into the yarn. Those who have upon them the responsibility of the production of first-class yarn must know what a relief this is.

Further than what I have described there is little to be said about draw-frames, with the exception perhaps of the coilers. In old days it was considered that fine yarns could not be spun from sliver coiled by a mechanical coiler, hence the old-fashioned plungers or travelling boxes, or even the circular can without any coiler motion. It has been found, however, by experience, that it is quite practicable to so coil the most delicate cotton that it is more certain to possess regularity of tension in coming out of the can and in subsequent operations, than by any of the old-fashioned methods; and a can of Sea Island sliver, well coiled by the draw-frame specially adapted for it, is an exceedingly pretty object, which shows what perfection the motions of the machine have been carried to.



No. 10A.—PATENT REVOLVING CLEARER MOTION WITH BALANCE WEIGHTS.

SLUBBING, INTERMEDIATE, ROVING AND JACK FRAMES.

These three machines, which intervene between the drawing and spinning, are for the purpose of reducing the drawing sliver into the form of a thread or rove of the required fineness, preparatory to its being spun into yarn.

To make good roving, is a most important object in cotton spinning. They ought to be uniformly level and even, and should be equally twisted all through. The slubber is the first machine, when the fibres, in their progress from cotton to yarn, receive any twist.

The only twist required is just sufficient to enable the roving to draw off nicely, and to give it the necessary strength. The amount of twist must obviously depend upon circumstances.

The drafts should be set out nicely and uniformly, not too much in one frame, or too little in another; a single draft should, in no case, exceed one in seven. The rollers, as in the drawing frame, must be set according to the staple of the cotton. To ensure good spinning, it is most essential to have good roving—level, even, and equally twisted all through. Loose boss top-rollers are now almost universally used in the drawing, slubbing, intermediate and roving frames. To ensure a clear yarn, the rollers should be in good condition, and kept clean and well oiled. To produce clear yarn, the flats and flyers should be continually picked, and cleared of all flat dirt and fluss. The machines should be thoroughly well cleaned every Saturday, and the differential box opened, cleaned, and oiled.

The steel rollers should be taken out and scoured regularly, and the stands cleaned and inlaid with pure tallow. All the driving wheels and boards around them, gearing, shafts, &c., should likewise be regularly cleaned, and new tallow laid on the necks of the shafts, &c. These machines are now made with better—and surer—winding apparatus than formerly, with stronger spindles, steel flyers, and single pressers, case-hardened rollers, stopping and lock motions, &c. As to whether the bobbin or the flyer should lead, there is now only one opinion, and that is in favour of the bobbin leading.

With the bobbin leading, the work of the differential motion is increased, so that it is absolutely necessary to have a better control over this apparatus. To meet this requirement the cone drums are made of larger diameter than heretofore, besides which they are driven much more rapidly, and are placed further apart, thus giving a longer strap, and, therefore, more uniform winding, with less strain on the strap. As the spindles are driven by tooth and pinion through a range of wheels direct from the frame shaft, they must start at one and the same time with the shaft, and a little before the bobbins; the differential apparatus is the medium through which the bobbins receive their motion, and not being positive, on account of the cone drum strap, cannot take up the backlash so quickly. With the flyer leading, there is a tendency to stretch the roving.

When the bobbin leads, the ends slightly slacken, but are at once taken up when the bobbins have got fairly into motion. Through the increased speed of the spindles and the almost universal use of single press flyers, it has become necessary to strengthen the spindles, so that they may be better able to stand the extra work, and better withstand the extra wear and tear.

Long collars have become very general, and the spindles are thus better able to stand the strain of the comparatively unbalanced single-press flyers. It is proved by experience that better work can be produced from the single than from double-press flyers, more especially when making a fine hank roving.

When true excellence alone is required, or for a very fine hank roving, flyers without pressers for soft bobbins are used, but the perfection of modern flyers and the necessity of keeping down the cost of production have led to the introduction of press bobbins up to as fine as a 30-hank roving. The press bobbins contain more than double the quantity of roving, and there is much less creeling required in the after processes. The best flyers are now made of solid steel, are much lighter than formerly, and will stand a finer polish. They are also free from cracks inside their hollow leg. Any roughness inside the legs catches the fibres of the cotton, makes bad work, and causes the ends to be continually breaking.

Machines, of course, have long been made to stop when the right amount of roving has been wound on the bobbins, and they are fitted with a lock-motion, by which, after stopping, the tenter cannot set the frame on again until she has doffed, until the empty bobbins have taken the place of the full ones, and until all is made ready for a fresh start. Before this motion was applied, the tenters frequently set the frame on again after it had been stopped in the ordinary way, by holding the strap on the fast pulley, until the bobbins were filled to the full extent allowed by the flyers, without breaking the ends. This, of course, made very bad work, the roving became ragged and stretched, and the flyer legs were much strained and thrown out of balance.

The production per spindle of these machines is greater than formerly, and a far better quality of work is turned off, besides which a tenter can watch more spindles with more ease and at the same cost. The machines work with far less breakage, and it is a very common thing for a set of bobbins to be filled without a single end breaking.

It is now generally admitted that a fair and moderate speed of spindles is most economical, and produces the best quality of work with a minimum of waste. The high speed of spindles attained some little while back, with its attendant waste, and inferior work, has gradually given way to more moderate rates of speed. The trite but true saying that work spoiled in the card room cannot be mended in the spinning is a good guide to go by.

Explanation of the Sun and Planet, or Differential Motion:—This motion works on the frame shaft, the twist half being made fast, while the other half that drives the bobbins is loose; on each half is fixed a wheel of 36 teeth, and instead of coming into contact with each other, there is a centre wheel of 120 teeth fitted loosely on the shaft, and working right between the twist and bobbin halves. These two halves of the differential motion are set opposite to one another, and close up to the sides of the centre wheel. Between the spokes of this centre wheel are two other mitre wheels, therefore, when the two halves are set close up to the centre wheel on each side, the four mitre wheels are all brought into contact with each other, and as the half that is made fast to the frame shaft revolves with the shaft, motion is transmitted to the half that drives the bobbins, by means of the wheels that are fitted between the spokes of the centre wheel of 120 teeth. Now, if the centre wheel remains stationary or moves round with the twist half, it is evident the bobbin half must be carried round at the same speed. On the other hand, if the twist half stands still, and the centre wheel revolves, the mitres between the spokes of the centre wheel revolve round the wheel of the twist half, at the same time moving the bobbin half in the same direction as the centre wheel, at the rate of two revolutions for every revolution of the centre wheel, so that the variable speed of the bobbin half is entirely effected by the motion of the centre wheel. Unless the centre wheel stands still, or revolves at the same rate as the twist half, the motion of the bobbin half cannot be the same as the twist half. If the centre wheel revolves in the same direction as the twist half, the bobbin half will lose two revolutions on the twist half for every revolution of the centre wheel, but if the centre wheel revolves in the opposite direction, it will gain in the same proportion; therefore, the taking-up of the bobbin is regulated by the motion of the centre wheel, and this motion is regulated by means of the cone.

One tooth of the rack wheel is shifted every time the bobbin rail goes up and down, and at every shift the cone drum strap is moved further on to the thick part of the cone; consequently, the speed of the bottom cone decreases more and more as the strap is worked or moves up the cone, and being connected with the centre wheel by a range of other wheels, it drives the centre wheel either faster or slower, and with it the bobbins.

THE RACK WHEEL should be set with the button to ½ tooth, otherwise the "ends" at one change will be slack, and the other change will be tight.

In left-handed speeds the bobbin leads. In right-handed speeds the flyer leads. For moving the rack (for cone strap) more or less, change the wheel on top of upright.

For moving the "hanger bar" quicker or slower, and thus altering taper of bobbin, change the wheel on the bottom of the upright. To make taper of bobbin longer or shorter, change the taper wheel.

TAKING-UP.—Always have the drum straps beginning level with the ends of the drums, and also have the frame beginning the first "row" on the bobbin exactly the proper tightness. This is done by the wheel on the end of the cone drum, or the wheel on the top of the upright. Regulate the remaining "rows" on the bobbin by rack wheel.

TO MAKE THE BOBBINS AN EXACT TAPER.—Run the lifting rail to the exact centre of the bobbin; move the hanger bar backwards and forwards, to see that the reversing screws do not dip; if they do, move the hanger bar bracket higher or lower, as the case may require.

Flyer leading: to make bobbin lead. Alter the wheel that works under the drum-end wheel to work above, thus causing the revolving plate wheel to run the reverse way. At the same time be careful to change the bent lever for a straight one, so as to counteract the reversing bevils, as they also are driven by the drum-end wheel.

In changing hank roving, if you cannot alter the lift enough by the lift pinion, change the wheel on the bottom of the upright. To lift quicker use a larger wheel.

If the twist wheel is too large to gear, then change the top shaft wheel.

THE CONE DRUMS.

The two cones are formed with mathematical correctness on the same parabolic curve, but are reverse of one another, the driving cone being concave or hollow in its length, and the driven being convex or bulging outwards in its curved line. Without this curvature it would be impossible to get correct or accurate winding; in fact, the curvature is essential to make compensation for having an equally divided rack. If this curvature of the cones were not applied, it would be necessary to have an uneven star wheel constructed so as to give slack to the wind as the bobbin gradually fills. If the cones were a straight taper, the winding would be too keen, more especially so when the strap arrives at the middle of the cones, and would, therefore, cause the roving to be stretched, for as the belt approaches the centre of the drums, and the diameter of the top and bottom cones become more equal, and the speed of the differential motion slower, the loss of speed is less, and thus it will readily be seen that the object of these curvature lines is to ease or slacken up the winding, which would otherwise, as before stated, be too tight. The drum belts invariably slip when starting up a frame on the bare bobbin, and this slippage is caused by the small diameter of the bottom or driven cone drum, together with the high rate of speed at which the differential motion is being driven. It will be observed that as the bobbin is gradually wound off in the mule the harder and more compact it becomes; on the other hand, the fuller the bobbin, the softer or more spongy it is, especially the latter half of the full bobbin.

So far, we have only spoken of the necessity for the cones, being concave and convex on account of the slippage of the strap, but there is likewise another reason which is to be found in the fact that the bobbin, as it becomes larger and larger in diameter, is not in exact proportion to the length being wound on; the diameter is greater with each layer than accountable for by either slippage or actual length, or both. The obvious explanation of this is that the cotton roving is of a soft and spongy nature, and during the process of winding it expands or swells out as it were, thus again increasing the diameter, and the extra amount of curvature given to the cones is to regulate or decrease the speed of the bobbin proportionally to this extra increase of diameter over and above the mathematically correct speed required on account of the roving not lying close and compact. We, therefore, see that the concave and convex form given to the drums decreases the speed of the larger centre wheel of the differential motion, which in its turn slightly and proportionately to the extra diameter spoken of, decreases the speed of the bobbin or taking up. If, for instance, a solid and unyielding substance such as steel wire were to be wound on to the bobbin, the diameter of the wire, multiplied by the number of layers put on, and this multiplied by two, with the diameter of the empty bobbin added, would give the diameter of the bobbin when full; but with cotton roving it is different; for, as before explained, the natural tendency of the cotton is to spring outward. This clever device—the cone drums and differential motion—for regulating the speed of the bobbin to its increasing diameter, when we remember the soft and yielding nature of the material to be wound, is undoubtedly and admittedly one of the most beautiful, interesting, and intricate problems in mechanics that has ever had to be solved.

The function of the slubbing, intermediate, roving, and jack frames being to take a roving furnished to it and reduce the thickness, whilst putting in the proper twist, to give the consistence necessary to support the drag for the next operation without stretching, it is evident that the principal work must be done in the rollers and in the flyer, therefore the exactness of the finish of these two organs is of vital importance. It is impossible to overrate the importance of thoroughly well finishing these articles. The flute of the bottom rollers has come to be a pretty well recognised standard which is very generally adopted by all machine makers. There exists even yet a considerable difference in the finish of the flyer. An idea seems to exist that an exceedingly carefully finished flyer is only necessary for combed yarns and fine numbers, but I can admit no principle of this kind, and whether it be for coarse or fine numbers the flier should be finished as well as possible. I must admit, of course, that in fine numbers, and especially in doubled-combed yarn, it is next to impracticable to work with the ordinary article of commerce; nevertheless this does not alter my view as to the importance of all work being perfectly finished. Given the rollers and flyers as they ought to be, and the bobbin on the spindle of correct diameter, it is evident that the other motions of the frame can only be those regulating the differential speed of the bobbin and flyer, for the purpose of winding when twisting and the lifting and lowering motion of the rail for the purpose of laying on the roving at correct distance. These motions vary a little in detail from one machine to the other, but in principle there is little or no difference, and the machine remains in its essential elements what it has been since the differential motion and the cone drums were first applied to it. It has, of course, shared the lot of all other machines in the mill by being subject to a considerable improvement in construction, all details of pieces, jointings, &c., having been carefully studied, and all revolving parts carefully balanced; lubrication and polishing of collars and footsteps, with a view of avoiding tremulous vibration and wear-and-tear, and increased facility for lubrication of all working parts; strengthened shafts, and substitution of steel for iron, comprise the principal points that have received attention. Just one point, perhaps, I might allude to as being worthy of consideration, especially in view of the importance I have attributed to the avoidance of flat waste on the spinning machinery. It is the substitution for the stationary flat cloth, or upper clearer cloth, or even the revolving cloth, of a revolving clearer covered with flannel cloth. In this case the back roller is self-weighted and of large diameter, and the clearer, if of correct diameter to start with, can be allowed to run for many days, even weeks, without requiring to be cleaned, and during all this time it is intercepting every stray fibre and forming a fine felted covering to the top clearer, effectually preventing any damage by falling flat-waste.

If it is considered that there are, however few, if any, real faults in the working of fly frames, attributable to the principles involved, it will be seen how difficult it must be to make any further essential change.

When examining some machinery in a local museum in Lancashire, I observed a fly frame that had been working from 1830 to 1890, and was then only replaced because the bobbins that it made were too small and did not contain sufficient length. This is strongly corroborative of what I have said about the small change that has taken place.

THE COMMON FLY THROSTLE.

The yarn produced from this machine, from its strength and smoothness, is extremely well adapted for warps. In the throstle frame the spindles on both sides are driven by cotton bands from the tin roller, extending from end to end of the machine. On the one end of the tin roller are the fast and loose driving pulleys, and from the tin roller shaft motion is conveyed to the iron rollers by a range of wheels and pinions. The roving, in passing through the three sets of rollers, undergoes a draft of from say 5 to 8 inches—according to circumstances; it is now twisted by the flyer, and wound on to the bobbin. The thread itself is of sufficient strength to bear the drag of the bobbin, and the velocity of the bobbin is retarded by friction, which can be increased or decreased to any degree that may be required, by means of washers of cloth, and being thus retarded, the thread, by the motion of the flyer, drags the bobbin round after it with a velocity equal to the difference between the speed of the flyer and the length delivered by the front rollers. The flyer is fixed on the spindle, and the flyer legs, which are solid, are twisted at their lower extremities, somewhat like a cork-screw. The thread is put through the guide wire, which keeps it steady, and conducts the yarn to the bobbin. The flyer, in revolving, rapidly communicates twist to the yarn. The bobbins rest on the bobbin rail, and are retarded by washers from revolving with the same velocity as the flyers, the thread is therefore wound on to the bobbin as fast as delivered by the front roller, whilst the lifter or traverse rail ascending and descending by a regular alternate motion, fills the bobbin equally from end to end. This alternate motion of the traverse rail is accomplished by means of a heart, and is called the heart motion; it is extremely simple, and can be understood at a glance. The highest range of counts spun on the common throstle is 34's and 36's, and very few of the latter. The yarn produced is stronger than that produced by the mule, but a throstle spindle cannot produce the same weight in proportion as a mule spindle.

When spinning from 40's to 50's on the common throstle, most spinners have their own special weight of bobbin, which they find from actual experience suits their particular description of yarn, and it is rarely found that two spinners use bobbins exactly alike, although spinning the same counts. The quality of cotton, strength of yarn, the twist and description of drag cloth--cotton listing is used by some spinners—have all to be considered in determining the pattern of bobbin to be used. It is also usual when spinning these Nos. on the common throstle to comb as well as card the cotton, and put it through an extra drawing frame and second intermediate. The heat of the room should be about 75 degrees Fahrenheit; if it gets below this the rollers begin to lick, causing more breakage and waste.

Any one of the six bobbins in annexed plate may be used when spinning from 40's to 50's out of long stapled cotton; but, of course, the diameter of the spindle blade should be borne in mind when ordering bobbins, on account of the size of the hole in the bobbin, and because a larger spindle exerts more force on the bobbin, and consequently the bottom flange of the bobbin must be slightly larger to counterbalance the effect.

No. 1 represents an ordinary throstle bobbin (2 in. lift, spindle $\frac{5}{16}$in. dia.) for 32's/34's American twist. By reducing the drag from $1\frac{11}{16}$in. dish to $1\frac{1}{2}$in. or $1\frac{3}{8}$in., making the top head $\frac{1}{16}$in. thinner, and keeping the barrel of the same diameter, it is possible to spin 40's/45's on this bobbin.

No. 2 represents a bobbin used by some spinners for 40's to 50's, and can be recommended for a trial.

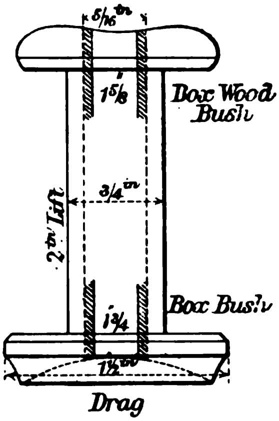
No. 3 represents a bobbin which can be highly recommended for fine counts. It will be found to answer very well for average 45's.

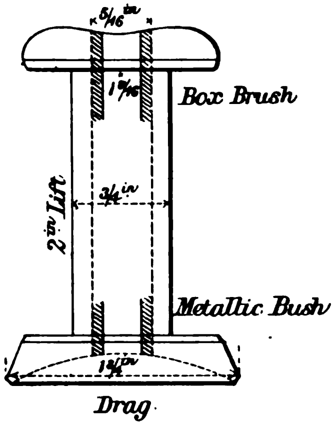
No. 4 represents a very suitable bobbin; it will be observed that the drag is even wider than the ordinary bobbin (No. 1) for 32's; it has also a metal bush in the bottom, which further increases its drag power; the top head being smaller reduces its weight a trifle, and causes less vibration in working.

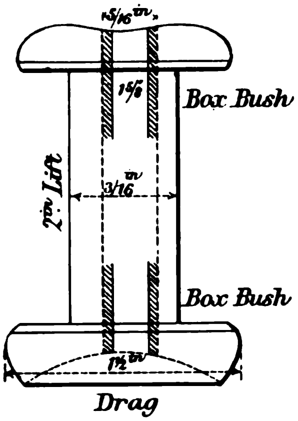
No. 5 represents a bobbin used for spinning 40's to 50's twist from long stapled cotton. The bore is for over $\frac{11}{32}$in. diameter of spindle, consequently it necessitates the drag being wider, as the spindle exerts more force than will be produced by a $\frac{5}{16}$in. spindle.

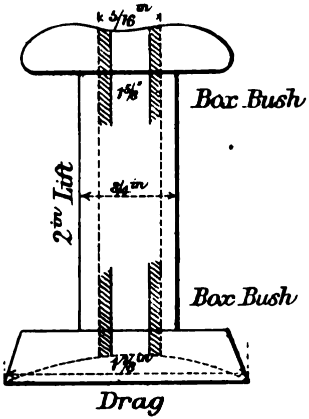
No. 6 represents a bobbin which is greatly in use for fine spinning. The bushes being so short, the spindles will have very slight power over the bobbins, therefore the drag will be stronger.

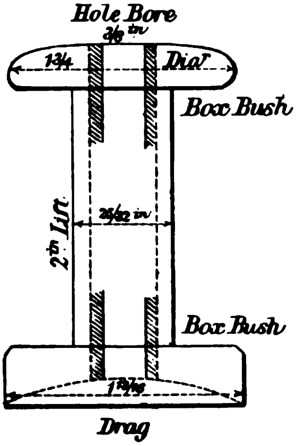
N.B.—When spinning these fine Nos. on the throstle, in consequence of the fineness of the yarn, a light

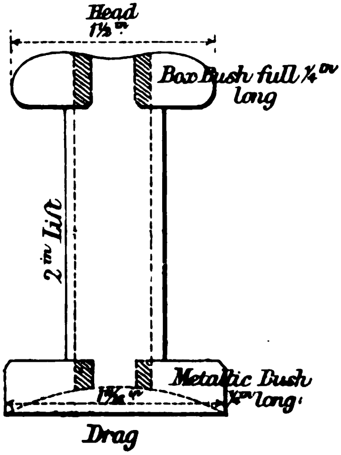

5/16 in
1 5/8
Box Wood Bush
3/4 in
2 in Lift
1 3/4
Box Bush
1 1/2 in
Drag


5/16 in
1 7/16
Box Brush
3/4 in
2 in Lift
Metallic Bush
1 3/4 in
Drag


5/16 in
1 5/8
Box Bush
3/16 in
2 in Lift
Box Bush
1 1/2 in
Drag


5/16 in
1 5/8
Box Bush
3/4 in
2 in Lift
Box Bush
1 7/8 in
Drag


Hole Bore
3/8 in
1 3/4 Diar
Box Bush
25/32 in
2 in Lift
Box Bush
1 13/16
Drag


Head
1 1/2 in
Box Bush full 1/4 in long
2 in Lift
Metallic Bush 1/4 in long
1 5/16 in
Drag

bobbin is required, with a very small drag; the larger and heavier the bobbin used the smaller diameter of drag is necessary.

THE SELF-ACTING MULE.

It would seem to be an impossibility to discover any new principle in the handicraft of spinning, whether it be cotton, flax, jute, wool, silk, or any other fibre. All the earliest historical references to spinning, and also the earliest inscriptions that deal with industries, tend to prove this. Further than that, in India and in some of the inland Asiatic countries where handicrafts are carried on to-day in the same manner as they were tens of centuries ago, the principle is precisely that of the machinery of to-day. This, although it may appear extraordinary, is not so much so if we consider that the only art of spinning yarn, in whatever material it may be, is the putting together of a sufficient number of fibres to make yarn of the thickness required, and then twisting these fibres together sufficiently to give them cohesion. From the first discovery of the possibility of replacing handicrafts by machinery, and an intermittent slow action by a continuous and rapid one, there has been little further change, except in detail. I have had an opportunity of inspecting in Bolton, Lancashire, where Crompton the inventor of the mule was born and bred, a singular and unique remnant of ancient invention in the shape of an old wooden spinning mule headstock, made and worked upon by Samuel

Crompton himself. This was purchased at a sale, and lent to the Industrial Museum in the town of Bolton. A singular point about this machine, and one that bears out my opening remarks, is that there is no motion in the most complicated self-acting mule of fine spinning numbers which has not got its counterpart off this old headstock; of course, some of the motions were performed by the hand, some by the knee, and others automatically, but every motion was represented in some one way or other, and thus it is that machine makers have been limited in improving mules to improvements in the details of the motions. The principle of a self-acting headstock has varied so little in the last twenty years that I do not consider it necessary to follow in any great detail the alterations that have been adopted. One result of the extreme competition has been that, as is the case with other machines, the speed of the mule has been pushed to an extreme, so that, where twenty years ago a speed of 550 of the rim-shaft was considered reasonable, it is nothing umcommon now to have 950.

In the old days, the driving for the backing-off and drawing-up was connected with the rim shaft by gearing; and as these two shafts were apparently close together, the variation of speed was limited, so that when the greater speeds were adopted, it was impracticable to bring down the speed of the backing-off and drawing-up in sufficient proportion; the gearing was, therefore, removed, and the driving applied to the backing-off and drawing-up shaft direct by rope or band. This was found to be very advantageous, as it allowed of a more delicate adjustment of speed, and the motions were put into action without the shock or jar that formerly accompanied the work of the gearing. The machines require a little more power, of course, with bands than they do with gearing, but this, in comparison with the advantages, is a small matter. There have been attempts made to equalise the twist by treble grooved and, I believe, even quadrupled grooved rim pulleys. The latter I have never seen, but the three-grooved rim pulleys I have seen, and can say that whatever slight advantage there may be in extra regularity of twist (about which I am by no means sure), that advantage is entirely annulled by the extraordinary difference of power required to drive these mules. With rim band of excellent quality (which all rim bands ought to be), and a proper system of taking up the slack, there ought to be little or no slip in the working. There may be a trifling amount when stopping and reversing for backing-off, and possibly a trifle when starting the spindles, but it is so little that it is not of practical importance. On the whole I may say that the power of the rim band on a mule of a thousand spindles is pretty near on a par with the practical value of the friction of the thousand spindle bands, and yet you will often find a person when specifying machinery insisting upon a long heavy spindle with the wharve of large diameter and treble grooved rims, apparently ignorant of the fact that although he may to some extent prevent slip in the rim-band by the use of treble grooves, he is reducing the control of the spindle band upon the spindle, and he risks a much greater inconvenience than a little slip of rim-band, viz., the unequal backing off of the various spindles, according to tightness of the spindle band.

As showing the difference of power required for the different sorts of spindles, I may say that the proportions are as follows:—

17½″	spindles	57
17″	„	39
14″	„	22

This should afford food for reflection, and when speed is required allowance must be made for the weight to be driven. An enormous amount of ingenuity has been expended upon motions for regulating the quadrant winding, and hardening and strengthening the nose of the cop. I may fairly say that their name is legion, and some of them are most ingenious and as near perfection as may be. These motions should, as far as practicable, be automatic, in the sense that they cannot be turned backward or forward by the workman; but if this should be done, the motion itself must rectify it at the next operation; in fact, a real self-acting mule should be, as far as practicable, independent of the skill of the workman.

In the self-acting mule the fine roving from the roving frame is drawn and spun into yarn of the required fineness. The rollers are set according to the length of the staple, and the amount of twist put into the yarn is regulated and determined by circumstances, such as the length and strength of the staple, whether twist or weft, counts, and according to order. In the mule the yarn is built on the bare spindle in the form of a "cop," and in such a manner as to throw little or no stress upon it, therefore this machine is used for spinning fine Nos. The yarn is also dragged; the amount of drag required is greater or more in long than short stapled cotton. The carriage recedes from the rollers as fast as the reduced rovings are delivered, the spindles at the same time revolve rapidly, and communicate the twist to the yarn. The distance which the spindles recede from the rollers is called the stretch, and when the spindles recede faster from the rollers than the yarn is given out, it is called the gaining of the carriage. When spinning fine Nos., the rollers stop after delivering a certain length of yarn, but the carriage continues to recede, and the spindles go on revolving; and even when the stretching is completed, the spindles continue still to revolve until the right amount of twist has been put in the yarn. As little twist as possible is put into the yarn before the jacking commences, only just sufficient to keep the fibres united, therefore a great amount has to be put in after the rollers have stopped. This naturally tightens the yarn, and unless the tension is reduced, the yarn is liable to break before the required amount of twist has been put in. In former times it was customary to cause the carriage to move inwards a little, in order to ease the tension of the yarn. This had the desired effect, but it shortened the stretch, and the carriage was difficult to regulate. Now, however, instead of moving the carriage, the rollers are made to revolve, and to deliver a small quantity of roving at a rate which can be varied at will, whilst the extra twist is being put into the yarn, and the result is very satisfactory. It is also customary when spinning out of long stapled cotton to cause the rollers to deliver from three to four inches of roving during the run in of the carriage, whilst the spun yarn is being wound on the spindles, and it is found that both the spinning and the yarn are greatly improved thereby.

In the self-acting mule there are two fallers, one the under or counter faller, with the wire beneath the yarn, and some half-inch below the spindle points; the other with the front or winding faller about one inch above the spindle points.

The back shaft causes the carriage to recede from the rollers, and when the receding carriage has reached its final or outermost position, that is, at the end of the stretch, and when the right amount of twist has been put into the yarn, the driving strap is shifted from the fast to the loose pulley, and the reversal of the tin roller causes the spindles to turn in an opposite direction, thus uncoiling the spiral of yarn that is coiled upon the bare spindles above the top of the cop. The backing-off now takes place, the counter faller rises, and at the same time the winding faller is brought down, and the wires of the two come in contact with the yarn, and acting against each other, regulate its tension and prevent it from slacking or snarling. During the return or run in of the carriage the yarn is wound upon the cop in the peculiar form given by the shaper.

The governor motion regulates the position of the quadrant nut, causing it to work up the screw of the quadrant. This screw is now made taper, and the entire motion is very reliable and accurate. The rail regulates from the shoulder to the nose of the cop, and the plates regulate from the shoulder to the bottom of the cop. The copping rail rests at each end on the front and back copping plates. The loose front incline is jointed at one end to the copping rail; its other end rests on the additional front copping plate, which is fastened to the ordinary front copping plate. The front and back copping plates are attached by a rod, and through the revolutions of the shaper screw the plates recede, causing the rail to fall. The lower the rail goes the higher the faller rises; and whatever bevil the copping rail may have will be the length of the chase given to the faller.

THE BACKING-OFF MOTION.

The operation of this motion is regulated automatically to suit the position of the cops at every successive stage during their formation, from winding the first stretch of yarn on the bare spindles, at the commencement of the cop, to the winding on of the last stretch, when the cop is completed. The copping apparatus is the controlling agent for regulating this motion, and is made with a separate loose front incline, and governed by the additional front copping plate. With the copping rail in one solid piece—as was formerly the case—only two points were capable of being adjusted to the exact positions required; but with the loose incline all the positions are regulated. The advantage of the latter over the former is the very important one of being able to regulate the precise position of the faller wire when the faller is locked. In the hand mule, when the spinner had depressed the faller to the proper position for winding, and uncoiled the exact or right amount of yarn from the bare spindles, he arrested the operation of backing-off, and commenced the winding on. This accuracy could not be attained with the copping rail in one solid piece, for the amount of inclination was determined by the conditions required to commence the cop on the bare spindles. At the commencement it was necessary to make the chase of the cop as short as possible, so as to prevent waste in the after processes. When the copping rail was set to its proper place at the commencement of the cop, the position of the faller wire was determined, and set at the position to suit the requirements of the operation; but immediately upon the winding part of the copping rail becoming more inclined, to enable it to wind a longer chase, then the front incline assumed a less inclined position, thereby leaving the faller wire, at the time of the faller locking, in a worse and worse position at each successive stretch or draw, until the chase has attained its greatest or maximum length, and had begun to be gradually shortened again. With the moveable front incline, its position can be so nicely and accurately regulated that the operation is an exact counterpart of the hand spinner's work; and by the use of the automatic apparatus for tightening the backing-off chain, in conjunction with the loose incline on the copping rail, the amount of yarn uncoiled from the spindles is regulated to suit the position of the faller wire at the termination of the backing-off. When once set this apparatus needs no further attention.

When the carriage is coming out the winding faller is generally about one inch above the spindle points; this is also the position of the parts immediately before the operation of backing-off the spiral of yarn that is coiled upon the bare spindles above the top of the cop. The reversal of the tin roller causes it to uncoil this yarn from the spindles, and also brings into action the parts which pull the faller wire down. It is evident the spindles begin to move before the faller wire is brought into action, as the tin roller must make some little movement before the backing-off click can take hold of the ratchet wheel. In addition to this, the spindles continue to uncoil the yarn during the time the faller wire is moving from its position above the spindle points, until it touches the yarn. It will, therefore, be seen that a certain length of yarn will be uncoiled from the spindles before the faller wire can overtake the yarn. The spindles thus have a considerable start, and at the completion of a set of cops this loss of motion or behind-handedness of the faller wire produces very bad results. In the case of a cop with its nose only $\frac{3}{4}$ of an inch from the spindle points, the loss is nearly one half the entire motion of the faller wire, which moves as far before it touches the yarn as it does after, so that it becomes necessary to have the backing-off chain tight, in order that it may act on the faller as quickly as possible; and the backing-off snail is made as large as possible, and of the proper form, so that the faller wire may act on the yarn at the earliest moment. At the commencement of a set of cops the conditions are very much more favourable; for, although the space actually passed through by the faller wire before it touches the yarn remains constant, it bears at the commencement a very much smaller proportion to the entire distance passed through by the wire before the faller locks than it does at the completion of the set of cops; consequently the backing-off chain has to be slack at the beginning of a set of cops, otherwise the speed of the faller wire would force the yarn down the spindles faster than it would uncoil, and would thereby break the thread. Hence, the backing-off chain having been adjusted to the proper length for backing-off nicely at the commencement of the set of cops, it is desirable gradually to tighten or shorten it as the cop increases in length, until, at the completion of the cop, the chain is almost tight. By this means the backing-off can be adjusted all through the set, so that it corresponds at every stage with the exact requirements of the case; the nose of the cop is preserved in a properly firm condition, and neither too much nor too little yarn is uncoiled. Next to winding the yarn properly on the cop, this is the most essential condition in making a good cop.

THE AUTOMATIC NOSING MOTION

Is a great improvement on Roberts' old winding apparatus. The only variation in the action of Roberts' quadrant was caused by the nut that worked up the screw of the quadrant arm, as it moved through the governor motion further outwards, from the centre of the quadrant, to suit the increasing diameter of the cop, until it had reached its full diameter. If the spindles had been of equal thickness where the cop is wound on to them, the winding on would have remained in each and every stage equally good. But this is not so; the spindles are taper, and as cops are now made much longer than formerly, it has become necessary to have a longer and stronger spindle, and consequently an increase in the amount of taper, the points of the spindles being always of the same diameter. As the cop bottom increases in diameter, the quadrant nut works up the screw of the quadrant arm, thus decreasing the speed of the spindles as they wind on the larger diameter of the cop, but imparting the full terminal speed to them when the winding reaches the nose of the cop. In Roberts' quadrant there was very little, if any, variation between the final speed and the commencement on the bare spindles. Now, the winding part of a cotton mule spindle tapers from ⅓ to 1-16th of an inch in diameter; and as it is most necessary in making a cop to wind the nose at each successive stage equally close and firm, the winding ought to be gradually modified, so that the terminal velocity of the spindles may be increased in the same ratio as their diameter decreases. This object is now attained by the Automatic Nosing Motion.

THE JACKING MOTION.

continues the outward run of the carriage after the rollers have ceased to revolve, in order that any thick places occurring in the yarn may be made uniform with the rest, its effect being that wherever there is a thin place in the thread, the greater portion of the twist runs into that part first, and thereby renders it more difficult to be elongated than the thick parts which are thus drawn down. The amount of jacking introduced varies from four to five inches, according to the staple of the cotton, the longest admitting of the greatest amount of jacking.

The general parts of the mule are made much stronger than formerly. Rim shafts now revolve at as high a speed as 950 revolutions per minute, driven by 5 inch straps. The backing-off and taking-in frictions have been enlarged to give them greater controlling power. The rods, levers, etc., have been strengthened to enable them to distribute properly the greatly increased power represented by the increased breadth and speed of the driving belt. The spindles are now made capable of revolving up to 11,000 revolutions per minute with cops on them 25% heavier than those formerly made.

Mules now work much more steadily and quietly, and are far less subject to stoppages from breakdowns, and are far better able to stand the strain of the extra work. Whereas in former times 24 hanks per spindle per week of 60 hours spinning 32's twist was considered good, the present production of a modern mill, working 56½ hours per week, is some 32 hanks per spindle, same counts. The quality of the yarn spun is fully 10 per cent. better as to strength.

The number of workpeople required for a pair of mules containing, say 2,000 spindles, is the same as before. The cops are made so much larger that fewer doffings are required for the same length of yarn; but taking the increased production into consideration, the actual amount of doffing labour is about the same.

The head-stock being much improved in its automatic movements, the minder can devote his attention more to piecing ends and looking after the younger piecers.

Altogether, the self-acting mule may be described as one of the cleverest and most wonderful pieces of mechanism in existence.

MACHINERY AND PARTICULARS OF 52,000 SPINDLE MILL SPINNING 32's to 70's.

1 Bale Breaker.
3 Openers.
4 Scutchers.
106 Cards.
11 Derby Doublers.
11 Ribbon Lappers.
122 Combers.
10 Drawing Frames.
8 Slubbers.
9 Intermediates.
16 Pairs Roving Frames.
32 „ Jack „
32 „ Mules

OPENERS.

One Porcupine of 6 Blades 18-in. diameter making 960 revolutions per minute. Fan of the same 1500.

One Beater 3 blades 18-in. diameter making 1030 revolutions per minute and the fan of same 1300.

Three yards of lap 33 ounces.

Draft (cal) 3·35.

PRODUCTIONS.

On Florida, Sea Island,	10,000 lbs.
On Egyptian	11,000 ,,

The above is for 54 hours.

SCUTCHERS.

Our Beater of two blades 18-in. diameter making 1150 revolutions per minute. Fan of the same 1200.

Weight of three yards of lap 28 ounces.

Draft (cal.) 3·92.

Production 8000 lbs. in 54 hours.

CARDS.

106 Cards (Simplex).
50-in. Cylinder.
24 ,, Doffer.
9 ,, Taker-in.
2¼ ,, Feed Roller.
110 Flats.
38-in. on the wire.
120's wires on the Cylinder.
130's wires on the Doffer and Flats.

SPEEDS.

FLORIDA SEA ISLAND:

Cylinder 170 revolutions.

Doffer 10½ revolutions.
Taker-in 425 „

EGYPTIAN :

Cylinder 170 revolutions.
Doffer 12¼ „
Taker-in 425 „

PRODUCTIONS.

On Sea Island 275 lbs.
„ Egyptian 450 „

DRAFTS.

On Sea Island 171·4.
„ Egyptian 126·3.

These cards are clothed with Sykes' hardened and tempered steel needle-pointed wire, and are ground once every three months.

All cylinders stripped twice per day.

Sea Island and Egyptian doffers four times per day.

All cards burnished ten minutes per week.

Taker-in covered with inserted metallic saw tooth wire.

Two and a half inch fluted feed roller with patent dish feed plate.

DERBY DOUBLER.

Doubling 14 ends and making a 6½ inch lap, weighing on Egyptian work 220 grains; and Sea Island 165 grains to the yard.

Total Draft 1·89.
Speed Front Roller, Sea Island 362.
„ „ „ Egyptian 362.

Productions.

Sea Island	2075 lbs.
Egyptian	3000 „

Ribbon Lapper.

Doubling 6 Derby Laps and making a Lap 7½-in. wide, weighing on Sea Island 190 grains, and on Egyptian 240 grains to the yard.

Total Draft.

Sea Island	5·20
Egyptian	5·86

Speed Front Roller, 300 revolutions.

Production.

Sea Island	2075 lbs.
Egyptian	3000 „

This machine is provided with a spoon stop motion at the back.

Combers.

Combers of 6 heads making 88 nips per minute.

Weights.

6	yds.	Sea Island	sliver	256 grains.
6	„	Egyptian	„	346 „

PRODUCING.

On Sea Island 200 lbs.
„ Egyptian 250 „

DRAWING FRAME.

Drawing Frames of three heads, of six deliveries each, spoon stop motion at the back and stop motion between front and calender rollers.

The four sets of top rollers are weighted at the ends with dead weights, and are all loose boss.

Speed of Front Roller 300.

Draft about six in. each head.

PRODUCTION.

From 2500 to 2800 lbs.

The Fine preparation produces a 12·80 hank bobbin for 60's and 70's counts.

The Medium preparation produces a 10·20 hank bobbin for 46's and 50's counts.

The Coarse preparation produces a 7½ hank bobbin for 32's, 36's and 40's counts.

Frame Particulars.

…………………	Draft.	Twist.	Hank.	Weight of 30 yards Grains.	Speed of Spindle.	Speed of Front Roller.	Hanks per Spindle per week of 54 hours.	Lbs. per Frame per week of 54 hours.	No. of Spindles in one Frame	Length of Lift.	Space of Spindle.
SLUBBER … … … …	—	—	—	—	—	—	—	—	80	10″	8″
Sea Island (fine) … …	5·23	·57	1·02	214	339	126	45	3530			
Egyptian (med.) … …	5·19	·53	·78	320	339	148	48	4923			
Egyptian (coarse) …	3·58	·44	·52	480	339	175	50	7692			
INTERMEDIATE … … …	—	—	—	—	—	—	—	—	98	9″	6½″
Sea Island (fine) … …	3·63	1·00	1·92	130	596	138	46	2348			
Egyptian (med.) … …	4·23	·89	1·65	151	596	154	50	2969			
Egyptian (coarse) …	4·12	·83	1·08	230	596	165	52	4718			
ROVING … … … … …	—	—	—	—	—	—	—	—	88	8″	5½″
Sea Island (fine) … …	4·61	1·80	5·10	49	659	93	32	552			
Egyptian (med) … …	4·81	1·74	4·03	62	711	104	37	807			
Egyptian (coarse) …	4·82	1·52	2·63	95	804	134	39	1305			
JACK … … … … …	—	—	—	—	—	—	—	—	120	7″	4″
Sea Island (fine) … …	5·21	3·	12·80	19½	1004	85	32	300			
Egyptian (med.) … …	5·09	3·	10·20	24½	1064	90	34	400			
Egyptian (coarse) …	5·51	2·40	7·50	33⅓	1064	111	33	608			

Mule Particulars.

	32	36	40	46	50	60	70
Speed of Rim.	669	669	669	669	669	669	669
Dia. of Rim.	17″	17″	18″	18″	18″	18″	18″
Speed of Spindle.	7092	7092	7492	7492	7492	7492	7492
Twist per Inch.	15	16	16·97	19·60	20·30	20·20	22·40
Roller Draft.	8·13	9·0	9·80	8·10	8·30	8·80	9·30
Gain.	4·30	4·75	4·75	5·0	5·0	5·75	5·75
4 Draws in Secds.	57	60	60	65	67	69	72
Hnks. per Spindle per week.	25	24·70	23·80	23·40	23·20	23·00	22·00

These Mules contain 800 spindles 1$\frac{3}{8}$″ gauge, are of 62-in. stretch, putting up 66-in. with roller motion, spinning double roving, loose single boss, front top rollers, weighted with dead weights, middle and back self weighed.

Bevel in Spindles, 5 inches.

MACHINERY AND PARTICULARS OF AN 80,000 SPINDLE MILL, SPINNING 70's TO 100's, ALL COMBED.—Florida Sea Island, Staple $1\frac{5}{8}$ to $1\frac{3}{4}$ long.

Machinery.

1	Bale Breaker.
2	Openers.
4	Scutchers.
101	Cards.
10	Derby Doublers.
10	Ribbon Lappers.
88	Combers.
8	Drawing Frames.
8	Slubbers.
20	Intermediates.
32	Roving Frames.
80	Jack Frames.
40	Pairs of Mules.

Openers.

One Porcupine of 6 Blades 18-in. diameter making 660 revolutions per minute. Fan of the same 1485 revolutions.

One Beater of 3 Blades 18-in. diameter making 875 revolutions per minute. Beater Fan 1458.

Weights.—3 yards of Lap 36 oz.

Draft (Cal.) 3·45.

SCUTCHERS.

One Beater of 2 Blades 18-in. diameter making 910 revolutions per minute. Fan of the same 1500 revolutions. Weight of 3 yards of Lap, 27 oz.

Draft (Cal.) 3·29.

CARDS.

101 Cards. (Simplex).
50 inch Cylinder.
24 ,, Doffer.
9 ,, Taker-in.
2¼ ,, Feed Roller.
110 Flats.
38 inch on the Wire.
120's Wire on the Cylinder.
130's ,, ,, Doffer and Flats.

SPEEDS.

Cylinder 160½ revolutions.
Doffer 11¾ ,,
Taker-in 400 ,,
Six yards of Sliver, 130 grs.

PRODUCTION.

275 to 300 lbs. in 54 hours.

Calculated Draft 152.

These cards are clothed with Sykes' hardened and tempered steel needle-pointed wire, and are ground once every three months; stripped every five hours; and burnished ten minutes per week; and have 2¼ in. fluted feed roller and patent dish feed plate.

Taker-in covered with inserted metallic saw tooth wire.

DERBY DOUBLERS.

Doubling 14 ends and making a Lap 6½ inches wide, weighing 166 grains to the yard. Spoon stop motion applied.

Total Draft 1·80.

Speed Front Roller, 362.

Production per 54 hours from 2,000 to 2,200 lbs.

RIBBON LAPPERS.

Doubling 6 Derby Laps, making a lap 7½ inches wide weighing 168 grains to the yard.

Total Draft in this Machine 5·04.

Speed Front Roller 228 revolutions.

Production per 54 hours from 2,000 to 2,200 lbs.

This machine is provided with a spoon stop motion at the back.

COMBERS

Combers of 8 deliveries making 86 nips per minute, working a lap 168 grs. to the yard and making a sliver, weighing to the 6 yards 246 grains or ·2 hank.

Production in 54 hours about 250 lbs.

DRAWING FRAME.

Drawing frames of three heads, of six deliveries each, spoon stop motion at the back, and stop motion between front and callender rollers.

The four sets of top rollers are weighted at the ends with dead weights, and are all loose boss.

The front roller 1½ inches diameter makes from 250 to 300 revolutions per minute.

A 9-inch can is used in the first and second heads, and an 8-inch can in the third or finishing head.

The Draft in each head is about 6.

Frame Particulars.

....	Draft.	Twist.	Hank.	Weight of 30 yds.	Speed of Spindle	Speed of Front Roller.	Hanks per Spindle per week 54 hours.	lbs. per Frame per week 54 hours.	Number of Spindl's in one Frame.	Length of Lift.	Space of Spindle.
				Grains.							
Slubber	5·11	·58	1·05	236	316	126	38	1809	50	10"	8"
Intermediate	4·40	1·06	2·42	103	591	128·6	42	1117	62	9"	6½"
Roving	4·95	2·07	5·95	42	701	86·3	29	594	122	8"	5¼"
Jack for 100's Yarn ...	6 13	3·69	18·50	13½	981·8	67·6	23	174	140	6"	4"
Jack for 70' & 80's Yarn	5·19	3·09	15·15	16½	981·8	77·5	27	249	140	6"	4"

Diameter of Bottom Rolls.

	FRONT.	MIDDLE.	BACK.
Slubber and Intermediate...............	1⅜"	1¼"	1⅜"
Roving and Jack.................	1¼"	1⅛"	1¼"

Mule Particulars.

	70's	80's	100's
Speed of Rim.	646	646	646
Dia. of Rim.	19	19	17
Speed of Spindle.	7648	7648	6845
Twist per inch.	23·14	23·80	27 10
Roller Draft.	8·88	9·52	9·52
Gain per Draw.	5½″	5¾″	6″
3 Draws in Seconds.	54	56	64½
Hks. per Sp. per week of 54 hours.	22	21·30	18·08

These mules travel out 60 inches, and put up with roller motion 64 inches per stretch; are of 1,000 spindles per mule of 1⅝-inch gauge, spinning double roving; loose single boss top rollers.

Diameter steel rollers, front 1⅛-inch; middle 1-inch; back 1⅛-inch.

Bevel in spindles 5½ inches.

MACHINERY AND PARTICULARS OF A 61,000 SPINDLE MILL, SPINNING 100's TO 150's, ALL COMBED.—SEA ISLAND.

MACHINERY.

1	Bale Breaker.
2	Openers.
3	Scutchers.
63	Cards.
7	Derby Doublers.
7	Ribbon Lappers.
48	Combers.
5	Drawing Frames.
5	Slubbers.
6	Intermediates.
16	Roving.
40	Jacks.
30	Pairs of Mules.

OPENERS.

One Porcupine of 6 Blades 18-in. diameter making 810 revolutions per minute. Fan of the same 1410 revolutions.

One Beater of 3 Blades 18-in. diameter making 925 revolutions per minute. The Fan 1324 revolutions.

Three yards of Lap 36 oz.

Calculated Draft about 3·50.

SCUTCHERS.

One Beater of 2 Blades 18-in. diameter making 943 revolvtions per minute. Fan of the same 904 revolutions. Weight of 3 yards of Lap, 27 oz.

Draft 4·87.

Cards.

63 Cards (" Simplex ")
50 inch Cylinder.
24 ,, Doffer.
9 ,, Taker-in.
2¼ ,, Feed Roller.
38 ,, on the Wire.
110 Flats.
120's Wire on the Cylinder.
130's ,, ,, Doffer and Flats.

Speeds.

Cylinder 158 revolutions.
Doffer 9½ ,,
Taker-in 400 ,,

Production.

250 to 300 lbs. in 54 hours.
Calculated Draft 152.
Six yards of Sliver. 130 grains.

These cards are clothed with Sykes' hardened and tempered steel needle pointed wire, and are ground once every three months; stripped every five hours; and burnished ten minutes per week; and have 2¼ in. fluted feed roller and patent dish feed plate.

Taker-in covered with inserted metallic saw tooth wire.

Derby Doublers.

Doubling 14 ends and making a Lap 6½ inches wide weighing 166 grains to the yard. Spoon stop motion applied.

Total Draft, 2.

Speed Front Roller from 350 to 370 revolutions per minute.

PRODUCTION.

From 2,000 to 2,200 lbs. in 54 hours.

RIBBON LAPPER.

Doubling 6 Derby Laps making a lap 7½ inches wide weighing 180 grains to the yard.

Draft in the Machine from 5 to 6.

Speed Front Roller from 220 to 240 revolutions.

Productions per 54 hours, 2,000 to 2,200.

This Machine is provided with a spoon stop motion at the back.

COMBERS.

Combers of eight heads making 86 nips per minute working a lap 180 grains to the yard and making a sliver 255 grains to 6 yards.

Production in 54 hours, from 240 to 260 lbs.

DRAWING FRAME.

Drawing Frames of three heads of six deliveries each, spoon stop motion at the back and stop motion between front and callender rollers.

The four sets of top rollers are weighted at the ends with dead weights and are all loose boss.

The front roller 1⅜ inches in diameter makes from 250 to 300 revolutions per minute.

A 9-inch can is used in the first and second heads, and an 8-inch can in the third or finishing head.

The draft in each head is about 6.

Frame Particulars.

20 Hanks for 100's and 110's.

....	Draft.	Twist per inch.	Hank.	Weight of 30 yards.	Speed of Spindle.	Speed of Front Roller.	Hanks per Spindle per week 54 hours.	Lbs. per Frame per week 54 hours.	Number of Spindles in one Frame.	Length of Lift.	Space of Spindle.
				Gr. 12yds.							
Slubber	5·12	·543	1·052	95	366	146	28·87	3136	84	10"	8"
Intermediate	4·41	·952	2·42	103	599	132	36·	1495	104	9"	6½"
Roving	4·91	1·93	6·97	41	733	96·4	24·47	632	162	8"	5¼"
Jack	6·23	3·90	20·00	12·5	982	64·5	22·10	220	200	6"	4¼"

Frame Particulars.

24 Hank for 120's, and 130's

....	Draft.	Twist per inch.	Hank.	Weight of 30 yards.	Speed of Spindle.	Speed of Front Roller.	Hanks per Spindle per week 54 hours.	lbs. per Frame per week 54 hours.	Number of Spindles per Frame	Length of Lift.	Space of Spindle.
Slubber........................	5·23	·86	1·09	Gr. 12 yds. 91½	293	119	28·87	3136	84	10"	8"
Intermediate	5·	1·75	2·85	87½	575	115	33·16	1207	104	9"	6½"
Roving........................	5·29	2·03	7·89	31·67	713	89½	28·50	585	162	8"	5¼"
Jack	6·	4·	23·94	10·44	954	60·4	19·70	164	200	6"	4¼"

Mule Particulars.

	100's	110's	120's	130's
Speed of Rim.	693	693	693	693
Dia. of Rim.	17″	17″	17″	17″
Speed of Spindle.	7372	7372	7372	7372
Twiss per inch.	27·12	29·78	31·77	35·74
Roller Draft.	9·22	9·80	8·77	9·61
Gain.	5″	5·48″	6·58″	6·58″
3 Draws in Seconds.	65	67	73	77
Hanks per Spindle per week.	17·15	16·71	15·60	13·65
—	—	—	—	—

CALCULATIONS.

To find the draft of a Dobson & Barlow opener with evener attached.

Multiply all the drivers with diameter of feed rollers for a divisor, then multiply all the drivens with diameter of Lap roll for a dividend, the quotient will be the draft.

Particulars of Openers.

Wheel on Lap Roller	50	driving.
„ „ Stud	13	
„ attached to Stud Wheel ...	50	„
„ on Cross Shaft	13	

Wheel on Stud	40	driving.
,, ,, Pulley Shaft	15	
,, ,, opposite end Pulley Shaft	79	,,
,, ,, Stud	36	
Rim Band Pulley	16″	,,
,, ,, ,,	8¼″	
Diameter Bottom Cone Drum	4⅜″	,,
,, Top ,, ,,	4½	
Worm on ,, ,, ,,	1	,,
,, Wheel	88	
On Axis of Worm Wheel	40	,,
Second Feed Roller Wheel	60	
On opposite end	22	,,
Feed Roller Wheel	27	
Diameter Feed Roller	2½″	
,, Callendar Roller	8¾″	

Example:

$$50 \times 50 \times 40 \times 79 \times 16 \times 4\tfrac{3}{8} \times 1 \times 40 \times 22 \times 2\tfrac{1}{2} = 1216600000000$$

$$13 \times 13 \times 15 \times 36 \times 8\tfrac{1}{4} \times 4\tfrac{1}{2} \times 88 \times 60 \times 27 \times 8\tfrac{3}{4} = 4226225503500$$

$$4226225503500 \div 1216600000000 = 3{\cdot}47 \text{ draft.}$$

To find speed of Porcupines from line shaft:—

Line shaft 160 revolutions.

Pulley on shaft 32″ driving.

,, counter shaft 16″

,, ,, 30″ driving.

Porcupine pulley 12″

Rule:

Multiply speed of line shaft with drivers for a dividend, then multiply drivens for a divisor.

Example:

$$\frac{160 \times 32 \times 30}{16 \times 12} = 800 \text{ speed of porcupine.}$$

To find speed of fan per minute:—
Porcupine 800 revolutions.
Pulley on Porcupine shaft 10″ driving.
Fan shaft pulley 6″
Example:

$$\frac{800 \times 10}{6} = 1333 \text{ speed of fan.}$$

If speed of fan is 1333 revolutions per minute with 6-inch pulley on fan shaft, what speed would a 7-inch pulley give.

Example:

$$\frac{1333 \times 6}{7} = 1142{\cdot}57$$

To find how many doublings a mill contains from the following particulars:

Opener	1
Scutcher ...	4
Card	1
Derby Doubler	14
Ribbon Lapper	6
Comber	8
Draw Frame	6-in each box 1st, 2nd, 3rd Boxes.
Slubber	1
Intermediate...	2
Roving	2
Jack	2
Mule	2

Rule.—Multiply all the doublings together and the product will be the doublings put in the yarn.

Example:

$$4 \times 14 \times 6 \times 8 \times 6 \times 6 \times 6 \times 2 \times 2 \times 2 \times 2 = 9289728$$

To find the speed of line shaft in card room.
Revolution of engine fly wheel 60
Diameter ,, ,, 24 ft.
Pulley on card room line shaft 9 ,,
Example:

$$\frac{60 \times 24}{9} = 160 \text{ revs. line shaft.}$$

To find speed of Cylinder in Carding Engine.
Revolution line shaft 160
Pulley on ,, 16″
Cylinder end pulley 15″
Example:

$$\frac{160 \times 16}{15} = 170 \text{ revs. of Cylinder.}$$

To find speed of Licker-in.
Revolution of Cylinder 170
Pulley on Cylinder shaft 10″
Pulley on Licker-in shaft 4″
Example:

$$\frac{170 \times 10}{4} = 425$$

To find weight of sliver produced by a card working 54 hours per week.

Rule.—Multiply diameter of doffer by 3·1416 the product will be the circumference of the doffer, then multiply by speed of doffer and the number of minutes in 54 hours, this product divided by 36 inches wil give the number of yards produced in one week, this multiplied by the number of grains in one yard and divided by 7,000 grains will be the production. Deduct from this 8 per cent. for stoppages, and the remainder will be what the card ought to produce in 54 hours.

Example:

Diameter of doffer with wire, 24¾ inches.

Speed of doffer per minute, 12.

Weight of one yard 35 grs.

Allowance for stripping, grinding, etc., 8°/₀.

$$\frac{24\frac{3}{4} \times 3{\cdot}1416 \times 12 \times 60 \times 54 \times 35}{36 \times 7000} = 420 \text{ lbs.}$$

Deduct 8°/₀ from 420 = 386·4 lbs.

To find the total draft in a card:

Rule.—Multiply all the drivers from coiler rolls to to feed roll, together with diameter of lap roll for a divisor, then multiply all drivens together with diameter of Coiler Callendar Rolls for a dividend, the quotient will be the total draft.

Particulars of a Card.

Bevil Wheel on end of Coiler Callendars	18	driving.
„ in Coiler Box	18	
„ on upright Shaft	22	„
„ „ Stud	22	
„ „ on end of which is a	19	„
Wheel on Callendar Roll of Card	38	
„ „ Shaft	33	„
„ Doffer	207	
Bevil „ Doffer End	26	
Side Shaft Bevil	32	
Side Shaft Draft Wheel	14	
Feed Roller Bevil	154	
On opposite end of Feed Roll	20	
Lap Roller Wheel	38	
Diameter of Lap Roll	4″	
„ Callendar in Coiler	2⅛″	

$$18 \times 22 \times 19 \times 33 \times 26 \times 14 \times 20 \times 4 = 7230263040.$$
$$18 \times 22 \times 38 \times 207 \times 32 \times 154 \times 38 \times 2\tfrac{1}{8} = 1239545172096.$$
$$1239545172096 \div 7230263040 = 171 \text{ draft.}$$

To find the surface speed of a 24-inch doffer—add ¾ in. to diameter of doffer for height of wire.

$$24\tfrac{3}{4} \times 3{\cdot}1416 \times 12 \text{ turns per min.} = 933 \text{ in. surface speed.}$$

The cylinder surface speed is obtained in the same manner.

If a card with a 14 side shaft wheel gives a draft of 160, what will a 13 give? Example:

$$160 \times 14 \div 13 = 172 \text{ draft.}$$

To find the length of fillet required to cover a cylinder.

Rule.—Multiply the circumference of cylinder by the width, and divide by the width of fillet.

Example: Cylinder 50″ diameter, 38 inches wide, fillet 2″ wide.

$$\frac{50 \times 3{\cdot}1416 \times 38}{2' \times 12'} = 248{\cdot}75 \text{ feet.}$$

Particulars of a Derby Doubler.

Lap Roller end	72 driving.
Wheel on end of Front Shaft ...	12
,, on other end of Front Shaft...	29
Callendar Roller Wheel...	72
On the same end of Callendar Roller.	90
Back Roller Wheel...	50
Diameter Back Roller	1½″
,, Lap Roller	12″

Rule.—To find the total draft of Derby Doubler, multiply and divide as in the Carding Machine.

Example:

$$\frac{72 \times 29 \times 90 \times 1\frac{1}{2}}{12 \times 72 \times 50 \times 12} = 518400 \div 281880 = 1{\cdot}88 \text{ draft.}$$

To find draft in draw-box only, multiply front roller wheel and the diameter of back roller for a divisor, then multiply back roller wheel and the diameter of front roller for a dividend; the quotient is the draft in draw-box.

Example:

$$\frac{28 \times 1}{50 \times 1} = 1{\cdot}78.$$

Note.—The reason the front roller wheel is not used in calculating the total draft is, because in that case it becomes a carrier wheel only. In this case the 28″ wheel on front roller drives a carrier, and this carrier drives back roller of 50 teeth.

RIBBON LAPPER.

Particulars:

Callendar Roller Wheel… …	78	driving.
Wheel on Cross Shaft … …	17	
Bevel Wheel … … … …	36	„
„ „ … … … …	18	
Wheel on driving end … …	62	„
„ „ front Roller …	75	
„ „ „ „ … …	20	„
Crown Wheel … … … …	65	
Draft „ … … … …	46	„
Third Roller Wheel… … …	55	
On the other end … … …	18	„
Double Carrier Wheel … …	35	
On the same stud … … …	34	„

Wheel on Back Roller	24	
Bevel Wheel on „	18	driving.
Bevel Wheel on Side Shaft ...	14	
On the other end	21	„
Stud Wheel	55	
On „	36	
On Wooden Lap Roller Wheel	48	
Dia. of Wooden Lap Roller ...	4″	
„ Lap Roller	12″	

To find total draft.

Example:

$$\frac{78\times36\times62\times20\times46\times18\times34\times18\times21\times36\times4'}{17\times18\times75\times65\times55\times35\times24\times14\times55\times48\times12'}=5{\cdot}70 \text{ draft.}$$

To find speed of Front Roller of Ribbon Lapper from Line Shaft.

Revolution of Line Shaft	160
Pulley on Line Shaft	22
„ „ Frame Shaft	10
Wheel „ „	62
Front Roller Wheel	75

Example:

$$\frac{160\times22}{10}=352 \text{ speed of Frame Shaft.}$$

$$\frac{352\times62}{75}=291 \text{ speed of Front Roller.}$$

To find the draft of a Dobson & Barlow Comber.

From the Coiler Callendar Rollers trace the drivers and drivens back to wooden feed roller, then multiply and divide as drafting a card.

Note.—Many persons become confused in taking the total draft of a Comber by attempting to work it out through detaching rollers, etc.; this is unnecessary.

Bevel Wheel on Coil Callendar Shaft	18	driving.
„ „ Upright Shaft	18	
„ Centre of do.	22	„
„ Stud Wheel	18	
Stud Wheel	60	„
Wheel on end of Cylinder	65	
On the other end Star Wheel Stud	1	„
Star Wheel	5	
Feed „	19	„
Wheel on end of Feed Roller	38	
Bevel on opposite end	21	„
Bevel Wheel	21	
Horizontal Side Shaft Bevel	20	„
Bevel Stud Wheel	55	
On its Axis	36	„
Lap Roller Wheel	49	
Diameter Coil Callendar	$2\frac{1}{8}$	
„ Wooden Lap Roller	4	

To find the draft.

$$\frac{18\times22\times60\times1\times19\times21\times20\times36\times4}{18\times22\times65\times5\times38\times21\times55\times49\times2\frac{1}{8}}=21\ 54 \text{ draft.}$$

To find the draft between feed and detaching rollers of a Dobson & Barlow's Comber.

Wheel on Feed Roller.	38
Feed Wheel.	19
Star „	5
„ „ Stud.	1
Index Wheel.	80
Cam Shaft Wheel.	80

Quadrant drives detaching roller around once in three nips.

Diameter—Feed Roller $\frac{3}{4}''$
„ Detaching Roller $^{15}/_{16}''$

Example :

$$\frac{38 \times 5 \times 80 \times 1 \times \frac{15}{16}''}{19 \times 1 \times 80 \times 3 \times \frac{3}{4}''} = 4{\cdot}17 \text{ draft.}$$

To find the speed of front roller in a drawing frame :

Speed of Line Shaft	160
Pulley on Line Shaft	20″
„ Frame Shaft	16″
„ „	14″
„ Front Roller	10″

Rule.—Multiply the speed of line shaft together with drivers for a dividend, then multiply all drivens for a divisor, and the quotient will be the speed of the front roller per minute :

$$\frac{160 \times 20 \times 14}{16 \times 10} = 280 \text{ revolutions.}$$

To find the draft of a drawing frame between 1st and 2nd rollers :

Wheel on Front Roller	18
„ Stud	40
„ same Stud	26
„ 2nd Roller	30
Diameter Front Roller	$1\frac{1}{2}''$
„ Second „	$1\frac{3}{8}''$

$$18 \times 26 \times 1\tfrac{3}{8} = 643{\cdot}5$$
$$40 \times 30 \times 1\tfrac{1}{2} = 1800$$
$$1800 \div 643{\cdot}5 = 2{\cdot}79 \text{ draft.}$$

To find the draft between front and back Rollers.

Front Roller Wheel	20 driving.
Crown Wheel	75
Draft	51 „.

Third Roller	60
Wheel on the other end	18 driving.
Stud Wheel	35
Wheel on same Stud	37 „
Wheel on Back Roller	25
Diameter Front Roller	1½″
„ back „	1⅜″

Example:

$$\frac{75 \times 60 \times 35 \times 25 \times 1\frac{1}{2}}{20 \times 51 \times 18 \times 37 \times 1\frac{3}{8}} = 6{\cdot}32 \text{ draft.}$$

To find the production of a 6 delivery drawing frame in 54 hours, making a $\frac{25}{100}$ hank sliver, front roller 280 revolutions per minute, and 1½″ diameter.

Rule.—Multiply the inches delivered from front roller per minute by 3,240, the number of minutes in 54 hours; reduce this product to yards, divide by 840 yards, and this quotient will be the hanks produced per delivery in 54 hours; divide by hank sliver, and the quotient will be the lbs. produced; this multiplied by 6, the number of deliveries will be the lbs. produced from 6 deliveries, deduct say 15% for stoppages, &c., and the remainder will be the actual weight the frame is capable of producing at the given speed of front roller.

Example:

1½″ × 3·1416 × 280 = 1319·472-in. delivered per minute.

1319·472 × 3240 minutes = 4275089·28-in. per week.

4275089·28-in. ÷ 36-in. = 118752·48 ÷ 840 = 141·37 hanks.

141·37 ÷ ·25 hank sliver = 565·48 lbs. per delivery.

565·48 lbs. × 6 deliveries = 3392·88 lbs.

PARTICULARS OF JACK FRAME.

Gearing to Front Roller:		
Twist Wheel	28	driving.
Top Cone	50	
On other end	40	„
Front Roller Wheel	115	
Gearing to differential motion from frame shaft:		
Twist Wheel	28	driving.
Top Cone	50	
Diameter Top Cone	6½	„
„ Bottom Cone	3½	
Bottom Cone Wheel	17	„
Wheel on end of Jack Shaft	75	
Jack Wheel	24	„
Sun „	125	
Long Sleeve Wheel	60	„
Wheel on end of Bottom Shaft	50	
Skew Bobbin Shaft Bevel	50	„
Bobbin Wheel	22	
Diameter of Bobbin	1⅛	
„ Rollers	1¼	
Gearing to Spindles from Frame Shaft:		
Wheel on Frame Shaft	60	driving.
„ Spindle „	50	
Skew Gear	50	
Spindle Wheel	22	
Front Roller Wheel	20	„
Crown Wheel	90	
Draft „	45	„
Back Roller Wheel	60	

To find speed of frame shaft from a given speed of front roller:

Example:

Speed of Front Roller	70
Twist Wheel	28
Top Cone	50
On the other end	40
Front Roller Wheel	115

$$\frac{50\times115\times70}{28\times40} = 359{\cdot}40 \text{ revolutions of frame shaft.}$$

To find speed of spindles per minute:

Wheel on Frame Shaft	60	driving.
„ Spindle „	50	„
Skew Gear	50	„
Spindle Wheel	22	„

Example:

$$\frac{60\times359{\cdot}4}{22}=980 \text{ speed of spindles.}$$

To find differential motion and bobbin speeds.

The differential motion speed is somewhat complicated, and a little more difficult than the ordinary speeds. It is worked out as follows:—

Rule.—Find the speed of Sun-wheel, which, when found, multiply by 2. It will be noticed that every revolution of Sun-wheel drives the Sleeve-wheel twice round; this applies only to frames where the bobbin leads the flyer.

The product added to the speed of Frame shaft will give speed of Sleeve-wheel per minute. When the spindles lead half revolution of Sun-wheel must be added to Frame shaft.

Example:

$$359 \times 28 \times 6\tfrac{1}{4} \times 17 \times 24 = 256320600$$

$$50 \times 3\tfrac{3}{4} \times 75 \times 125 = 1757812{\cdot}5$$

$$256320600 \div 1757812{\cdot}5 = 14{\cdot}58$$

Speed of Sun-wheel:

14·58
2

29·16
359· **Speed long sleeve wheel.**

388·16

To find speed of bobbins from differential motion:

$$\frac{388{\cdot}16 \times 60 \times 50}{50 \times 22} = 1058 \text{ speed of bobbin per minute.}$$

Subtract speed of spindles from speed of bobbins, and the remainder is the number of layers wound on bobbin per minute.

Example:

1058
980

78

Length delivered by rollers per minute:

3·1416
1¼ **dia. front roller.**

3·9270
70 **speed front roller.**

274·8900 **inches delivered per minute**

Length wound on bobbin per minute:

3·1416
1⅛

3·5343
78

275·6754 **in. wound on bobbin**

Subtract length delivered by rollers from length wound on bobbins and the difference is the gain of bobbins over roller or *vice versa* if rollers deliver more than is wound on by the bobbins.

Note.—The reader will notice the top cone is figured ¼″ less and the bottom cone ¼″ more. The sizes here given are measured from the centre of cone belt as it stands on cones immediately after doffing. The reason for this is on account of the belt not having the proper purchase, caused by the tapering surfaces of the cones.

This it will be found is equivalent to allowing 10% slippage on the speed of sun-wheel per minute, with the diameters of cones 3½″ and 6½″.

The writer has noticed in some mills where a very wide drum-belt is used, the slippage or loss of speed is still greater than 10%

This point, however, can be determined by the overseer himself, by indicating the speed of the sun-wheel in the frames. A thorough carder will always endeavour to adjust this motion so as to prevent the bobbins over-running the speed of the rollers, and thereby stretching the rovings; this is very important, especially where the roving is twisted soft.

To find the twist per inch.

Rule.—Divide speed of spindle per minute by length delivered from front roller, the quotient will be the twist per inch.

Example:

980 ÷ 274·89 = 3·5 turns.

To find twist-wheel when changing from a coarse to a finer hank roving.

Rule.—The square of the twist-wheel is multiplied by the present hank and divided by the hank required, the square root of the quotient will be the twist-wheel required.

Example:

28 twist-wheel working 18 hank roving, what twist-wheel will be required for 24 hank roving.

$$\frac{28\times28\times18}{24}=588=24 \text{ twist-wheel.}$$

In changing from fine to coarse roving, square twist-wheel as before, multiply by the present hank, and divide by the hank required, the square root of the quotient will be twist-wheel required. The above rule also applies to lifter and strike wheels.

To find draft in jack frames:

Front Roller Wheel	20
Crown „	90
Draft „	45
Back Roller	60
Diameter Front Roller	1¼″
„ Back „	1¼″

Rule.—Multiply front roller and draft-wheel together, with diameter of back roller for a divisor, then multiply crown and back roller-wheels together, with diameter of front roller for a dividend, the quotient will be the draft.

$$\frac{90\times60\times1\tfrac{1}{4}}{20\times45\times1\tfrac{1}{4}}=6$$

To find a draft pinion to give a required draft of 6.

Example:

$$\frac{90\times60\times1\tfrac{1}{4}}{20\times6\times1\tfrac{1}{4}}=45 \text{ Draft pinion.}$$

To find draft-wheels in changing from a coarser to a finer hank roving, or *vice versa.*

If the draft pinion is a 45 making a 16 hank roving, what pinion would be required for a 20 hank?

Rule.—Multiply draft pinion by the present hank and divide by the hank required.

Example:

$$\frac{45 \times 16}{20} = 36 \text{ Draft wheel.}$$

To find star wheel in changing from one hank to another. If the star wheel is 40 working a 16 hank roving, what wheel would be required for a 20 hank?

Rule—Multiply the square of star wheel by the hank required, and divide by the present hank, extract the square root of the result, and the quotient will be the star wheel required.

Example:

$$40 \times 40 \times 20 = 32000 \div 16 = 2000$$

the square root of which is 44·7 or 45 star wheel.

All the calculations given here will apply also to the Slubbing, Intermediate, and Roving Frames.

PARTICULARS OF SELF-ACTING SPINNING MULE.

Speed Main Shaft	240
Main Shaft Pulley	24″
Fast and Loose Counter Shaft Pulley	16″
Counter Shaft Pulley	27″
Pulley on Rim Shaft	15″
Driving to spindles from Rim Shaft:	
Rim Pulley	18″
Cylinder Pulley	11″
Diameter Cylinder	6″

Diameter Spindle Wharves ... ... $\frac{7}{8}''$

Driving to back shaft from rim shaft:

Wheel on Rim Shaft ...	18	teeth driving.
Stud Wheel	49	
On the other end	35	„
Drawing-out Wheel	90	
Bevel on Drawing-out Shaft ...	45	driving.
„ „ Front Roller Spindle...	35	
Roller-box Wheel	55	„
Gain	72	
Stud	16	„
Back Shaft	60	
Diameter Front Roller	$1\frac{1}{16}''$	

Diameter of back shaft scrolls, $5\frac{1}{4}$-in.; add to this the width of the band that in practice is found to be necessary; the diameter of scroll with a $\frac{3}{8}$ band would then be $5\frac{5}{8}$. The length of stretch is 66 inches.

To find speed of rim.—Example:

Speed of line shaft 240 revolutions; pulley on line shaft 24″ driving; 16″ on counter shaft, 27″ pulley driving, 15″ on rim shaft.

Rule.—Multiply all drivers with speed of line shaft for a dividend, then multiply all drivens for a divisor, the quotient will be the speed of rim shaft.

$$\frac{240\times 24\times 27}{16\times 15}=648 \text{ speed of rim.}$$

To find speed of spindles.

Rule.—Multiply speed of rim shaft, diameter of rim and cylinder for a dividend; then multiply diameter of cylinder pulley and spindle wharve for a divisor, the quotient will be speed of spindle per minute.

Example:

$$\frac{648 \times 18 \times 6}{11 \times \frac{7}{8}} = 7271 \text{ speed of spindles.}$$

To find speed of front roller per minute.—Multiply speed of rim shaft and all drivers for a dividend, then multiply all drivens together for a divisor.

Example:

$$\frac{648 \times 18 \times 35 \times 45}{49 \times 90 \times 35} = 119 \text{ Revolution of front roller}$$

To find speed of carriage per minute during outward run.

Rule.—Multiply speed of front roller by the drivers for a dividend: then multiply the driven wheels together for a divisor, the quotient will be speed of back shaft. Multiply this quotient by the circumference of scroll, allowing for the thickness of the squaring band, and the result will be the rate of speed the carriage travels during its outward run.

Example:

$$\frac{119 \times 55 \times 16}{72 \times 60} = 24{\cdot}24 \text{ speed of back shaft.}$$

$$3{\cdot}1416 \times 5\tfrac{5}{8} \times 24{\cdot}24 = 428\ 3 \text{ inches, speed of carriage.}$$

To find twist per inch in yarn.

Rule.—Find the number of turns of spindle for one of the rim, then multiply by the number of teeth in twist-wheel, and divide by the total length of stretch.

Example:

$$\frac{18 \times 6}{11 \times \frac{7}{8}}\ 11{\cdot}22 \text{ turns of spindle} \times 120 \div 66 = 20{\cdot}4 \text{ turns per inch.}$$

To find running twist or the amount of twist put in yarn during the outward run of carriage.

Rule.—Divide the number of turns of spindle per minute by speed of carriage, and the quotient will be the running twist per inch of yarn.

Example:

7271 speed of spindles ÷ 428·3 = 16·97.

To find the head twist.

Rule.—Subtract running twist from total turns per inch of yarn, and the remainder will be the head twist

Example:

20·4 − 16·97 = 3·43 twist.

of yarn, or 17 per cent. of the total twist put in the yarn whilst the mule is at the end of its outward run.

To find the draft.

Rule.—Multiply the front roller wheel draft pinion, and diameter of back roller for a divisor, then multiply crown wheel, back roller wheel, and the diameter of front roller for a dividend.

Example:

$$\frac{120 \times 50 \times 1\frac{1}{16}}{18 \times 45 \times 1\frac{1}{16}} = 7{\cdot}4 \text{ draft.}$$

To find gain of carriage per stretch.

Rule.—Divide speed of carriage by length delivered from rollers and the fraction over one multiply by the length of stretch.

$1\frac{1}{16}$ × 3·1416 × 119 revolutions front roller = 397 in. delivered per minute.

Example:

428 ÷ 397 = 1·078

·078 × 62* = 4·83 gain of carriage over the rollers in 62 inches of length travelled by carriage.

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* NOTE.—The carriage when at the beam is adjusted to allow the spindles to stand 4 inches from rollers, and when at the limit of its outward run the spindles are 66 inches from rollers, consequently the carriage travels 62 inches every run of carriage, and 4 inches are delivered by rollers during the return of carriage to the beam.

To find how many hanks per spindle a mule is producing, say the mule has 1000 spindles producing 350 lbs. of 70's in 54 hours, how many hanks will it produce per spindle ?

Multiply the lbs. produced by counts spun, and divide by the number of spindles.

Example :

$$350 \times 70 = 24500 \div 1000 = 24\tfrac{1}{2} \text{ Hanks.}$$

To find how many lbs. of yarn a pair of mules is capable of producing per week, 1 pair of mules, 2000 spindles in a pair, 54 hours time a week, 3 draws in 50 seconds, 70's counts.

Rule.—Reduce 54 hours to seconds, divide this answer by 50, and multiply by 3 the number of draws in 50 seconds, then multiply by 66 length of draw, and reduce the amount to hanks, then multiply by the number of spindles in a pair, deduct 10 °/₀ for loss in scouring, etc., and divide by 70, and the quotient will be the number of lbs. capable of being produced.

Example :

$$\frac{54 \times 60 \times 60}{50} = 3888$$

$$\frac{3888 \times 3 \times 66}{12 \times 34 \times 840} = 25.45 \times 2000 = 50900 - 10\% = 45810 \div 70 = 654 \text{ lbs.}$$

To find how many revolutions of the spindle to the rim one.

Rim 18″
Cylinder Pulley 11″
Cylinder 6
Spindle Wharve $\frac{7}{8}$″

Multiply the diameters of the rim and cylinder together for a dividend, then multiply diameters of cylinder pulley and spindle wharf for a divisor, the quotient will be the turns of the spindle for the rim one.

Example:

$$\frac{18 \times 6}{11 \times \frac{7}{8}} = 11{\cdot}2 \text{ revolutions of spindle for one of rim.}$$

To find the twist-wheel required to spin 100's with $27\frac{1}{2}$ turns to the inch from the following particulars:—Diameter of rim 18″, cylinder pulley 11in., cylinder 6″, spindle wharf $\frac{7}{8}$″, length of stretch 64in., find speed of spindle as before for one of rim,

$$\frac{18 \times 6}{11 \times \frac{7}{8}} = 11{\cdot}2$$

then multiply length of stretch by turns required and divide this product by turns of spindle for one of rim.

$$64 \times 27\tfrac{1}{2} = 1760 \div 11{\cdot}2 = 157$$

twist wheel, or a 79 twist wheel twice around.

To find drawing out wheel.

If there is a 90 drawing out wheel spinning 60's, what would be required to spin 70's?

Rule.—The square of drawing-out wheel at present on, multiplied by the counts required and divided by the counts being spun, the square-root of this quotient will be the drawing-out wheel required.

Example:

$$90 \times 90 \times 70 = 56700 \div 60 = 9450,$$

the square-root of which is 97 drawing-out wheel required.

Note.—This rule also applies to finding the twist and builder wheels.

To find the draft-wheel in changing from one count to another:

Suppose we have a 50 draft-wheel, spinning 100's, what wheel would be required for 120's?

Rule.—Multiply the draft-wheel on by counts being spun, and divide by counts required.

Example:

$$\frac{50 \times 100}{120} = 42 \text{ draft-wheel.}$$

WRAPPING.

To find the number of counts spun.

For wrapping the roving and yarn in card and spinning rooms, there are two reels used; the one used in the card room is one yard in circumference, whilst the one in the spinning room is 54 inches in circumference, and is so constructed that for every turn of the handle the reel wraps 108 inches or goes twice around. A table composed of Troy and Avoirdupois Weights is used; the reason for this is, owing to a very small weight being necessary so as to allow of perfect accuracy in wrapping.

Both are here given.

AVOIRDUPOIS WEIGHT.

$27\frac{34}{100}$ grs.=1 drachm.
16 drachms=1 oz.
16 oz.=1 lb. or 7,000 grs.

TROY WEIGHT.

24 grains=1 dwt.
18 dwts. $5\frac{1}{2}$ grs.=1 oz.
16 oz.=1 lb. or 7,000 grs.

120 yards=1 lea—7 leas=one hank or 840 yards=

No 1 counts—

840 yards or 1 hank of yarn, weighs 7,000 grains or 1 lb.

If 1 lea or 120 yards of yarn weigh 32 grains, what counts will it be?

Explanation:—

It is evident if 7 leas of No. 1^s=7,000 grs., 1 lea must=1,000 grs.

Example:—

Divide 1,000 grs. by 32 and the quotient will be the counts.

1,000÷32=31·2^s counts or 31·2 hanks to 1 lb.

If two leas of yarn weigh 64 grs., what counts will it be?

Example:

2,000 grs.÷64 grs.=$31\frac{2}{10}$counts.

If 30 yards of roving weight 20 grs. what will be the hank roving? If 1 lea or 120 yards of No. 1^s=1000 grs., 30 yards or $\frac{1}{4}$ of a lea must=250 grains.

250 grs.÷20=$12\frac{1}{2}$ hank roving.

If 60 yards of roving weigh 40 grs., what will be the hank?

If 1 lea or 120 yards of No. 1^s=1,000 grs., 60 yards =$\frac{1}{2}$ a lea or 500 grs.

500 grs.÷40=$12\frac{1}{2}$ hank roving.

If 15 yards of slubbing weigh 120 grains, what will be the hank? 15 yards being $\frac{1}{8}$ of one lea, or $\frac{1}{8}$ of 1000 grains = 125 grains ÷ 120 = 1·041 counts.

If 6 yards of drawing weigh 250 grains, what hank drawing will it be?

As 6 yards of No. 1's weigh 50 grains, 50÷250=·2 hank drawing.

If 1 yard of card lap weighs 11 oz., what will be the hank?

Rule.—Reduce the weight of one yard to grains—11 oz.×18·23 (dwts. in 1 oz.)×24 (grains in 1 dwt.) =4812·72 grains this × 840 yards in 1 hank for a divisor, and 7000 grains for a dividend, will give the hank which is ·0017.

Another Rule—

Reduce 11 oz. to grains as before for a divisor, and 8·33 grains the weight of 1 yard of No. 1's yarn for a dividend, the quotient will be the same, ·0017 hank.

STANDARD TWISTS.

To find the twist necessary per inch for a 16 hank roving spinning Sea Island cotton ·85 standard.

Rule.—The square root of the hank roving multiplied by the standard given will be the twist required.

Example:

16=4 square root × ·85 = 3·40 turns per inch.

Note.—In spinning ordinary American the standard used is 1·20, the standard given above for Sea Island is most generally adopted, and in slubbing and intermediate roving it will be found that the work will run very satisfactorily with still less twist than here given.

To find twist per inch spinning 100's Sea Island.

Rule.—The square root of the counts multiplied by 2·75 = 27·5 turns per inch.

To find twist per inch spinning 36's for hosiery purposes.

Rule.—The square root of the counts, 6, multiplied by 2 50=15 turns per inch.

To find draft required to spin 100's on the spinning mule from 18 hank roving doubled, 18÷2=9, hank doubled, 100÷9=11·1 draft.

Now, there is a draft in the gain of the carriage over the rollers which must be taken into consideration. The total length of stretch is 64 inches say, gain of carriage 6 inches in 64 inches, or 58 inches delivered by the rollers and drawn out to 64 inches by the carriage. 6÷58=·103 draft in carriage leaving a draft of 10·997 in the rollers.

To find the average counts a mill is spinning.

The mill produces in one week

3000 lbs.	...	32's
8000 „	...	36's
10000 „	...	50's
4000 „	...	60's
2500 „	...	70's

What average counts is the mill spinning?

Rule.—Multiply the different counts by the number of lbs. spun; these products add together, and divide by the total number of lbs. produced of all numbers.

Example:

3000 lbs.	...	32's	...	96000
8000 „	...	36's	...	288000
10000 „	...	50's	...	500000
4000 „	...	60's	...	240000
2500 „	...	70's	...	175000
27500				1299000

= 47·24 average counts.

PERCENTAGES.

Suppose the scutching-room is required to produce 10% more weight than before changing; you are now running with a 10 oz. lap. What weight of lap per yard would you require?

Example:

10% of 10 oz. = 1 oz. + 10 = 11 oz. lap.

If 100 lbs. of cotton in passing through the scutching room loses 3lbs., what will be the percentage of loss? Add two ciphers to the three and ÷ by 100.

Example:

3·00÷100=3%.

If 97 lbs. of card laps loses 7 lbs. in passing through the card, what is the percentage of loss?

Example:

7·00÷97=7·21.

If 50 nips of a comber produce 240 grains of sliver and 36 grains of waste, what is the percentage of comber waste?

Rule.—Add the weight of waste and sliver together for a divisor, then the weight of waste for a dividend, the quotient is % of waste.

Example:

36÷276=13% of waste.

Say the production of a mill was 25,000 lbs. of yarn per week, and in passing through the various machines the loss in waste and invisible loss was 30°/₀, how many lbs. of cotton would be required to feed on the Opener to produce 25,000 lbs. of yarn?

Rule.—Divide the amount of yarn spun by 70, the per cent. of yarn received from the cotton, and multiply this quantity by 100.

Example:

$$25000 \div 70 = 357{\cdot}14 + 100 = 35714 \text{ lbs.}$$

If the production of a mill was 25000 lbs. of yarn, and each card was to produce 500 lbs. of sliver per week, with a loss from card sliver to mule yarn of 20°/ₒ, how many cards would be required?

Example:

$$25000 \div 80 = 312{\cdot}5 \times 100 = 31250 \div 500 = 62\tfrac{1}{2} \text{ Cards.}$$

To find the counts produced on a mule from a given number of drafts and doublings.

Suppose the sliver at the drawing frame is ·25 hank and you double 2 at the intermediate, 2 at the roving, 2 at the jack, and 2 at the mule, with the following drafts: Slubber, 5; intermediate, 4; rover, 5½; jack, 6; and mule, 9. What counts will the yarn be?

Rule.—Multiply the doublings together for a divisor, then multiply the drafts together with the hank of the machine from which the calculation is to commence from for a dividend, and the quotient will be the counts.

Example:

$$\frac{{\cdot}25 \times 5 \times 4 \times 5\tfrac{1}{2} \times 6 \times 9}{2 \times 2 \times 2 \times 2} = 92\text{'s counts.}$$

The different places to change in passing the cotton through the various machines:

Opener: Alter draft by the evener.

Scutcher: Alter draft by the evener or side shaft bevels driving to cones.

Card: Side shaft wheel for draft, and Barrow or doffer wheel for speed.

Derby Doubler and *Ribbon Lapper* Draft pinion.

Comber: Feed wheel. Angle of top comb setting, and in the times.

Drawing Frame: Draft pinion.

Jack Frame: Draft.
Twist.
Lift.
Star.
Bottom Cone Drum.

Mule:

Draft.
Twist wheel.
Rim.
Draw out.
Gain.
Builder.

SLIVER TABLE.

Grains, Per Yard.	Number.	Grains, Per Yard.	Number.	Grains, Per Yard.	Number.
120	·0695	82	·102	56	·148
110	·076	78	·107	54	·154
102	·082	74	·113	52	·160
98	·085	70	·119	50	·167
94	·089	66	·126	45	·185
90	·093	62	·134	40	·208
86	·097	60	·139	35	·238
83·3	·100	58	·144	30	·278

TABLE OF DIVIDENDS FOR ANY LENGTH OF SLIVER. ROVING OR YARN.

Inches.	Dividends.	Yards.	Dividends.	Yards.	Dividends.	Yards.	Dividends.
9	2·083	1	8·333	7	58·333	20	166·
18	4·166	2	16·666	8	66·666	30	250·
24	5·553	3	25·	9	75·	40	333·333
30	6·944	4	33·333	10	83·333	60	500·
33	7·638	5	41·666	12	100·	80	666·666
33	8·333	5	50·	15	125·	120	1000·

TABLE

Showing the twist per inch, and the laps per inch on the bobbins according to the size of the roving.

Hank Roving.	Twist Per Inch.	Laps per Inch in the Lift.	Hank Roving.	Twist Per Inch.	Laps per Inch in the Lift.
	·84	6·5	6	2·93	22·7
¾	1·03	8·0	6½	3·05	23·7
1	1·20	9·3	7	3·17	24·6
1¼	1·34	10·4	7½	3·28	25·4
1½	1·46	11·3	8	3·39	26·3
1¾	1·58	12·3	8½	3·49	27·1
2	1·69	13·1	9	3·60	27·9
2¼	1·80	13·9	10	3·79	29·4
2½	1·89	14·7	11	3·97	30·8
2¾	1·98	15·4	12	4·15	32·2
3	2·07	16·1	13	4·32	33·5
3¼	2·16	16·7	15	4·64	36·0
3½	2·24	17·3	20	5·36	41·5
3¾	2·32	18·0	25	6·00	46·5
4	2·40	18·6	30	6·57	50·9
4¼	2·47	19·1	35	7·09	55·0
4½	2·54	19·7	40	7·58	58·8
4¾	2·61	20·2	45	8·04	62·5
5	2·68	20·7	50	8·48	65·7
5½	2·81	21·8			

Under this head, we will say that no carder of experience imagines that in making good roving of any description he can work from January till December with the same twist on the same counts. The cotton and the weather demand adjustment of the twist from time to time, and to give close attention to this, as well as to good drawing in all the processes, forms an important factor in successful spinning.

A TABLE

SHOWING THE SQUARE ROOT OF THE NUMBERS OR COUNTS, FROM ONE TO TWO HUNDRED HANKS IN THE POUND, WITH THE TWIST PER INCH FOR DIFFERENT KINDS OF YARN.

The heavy figures opposite No. 1 show the multipliers for the square root of all numbers throughout the tables.

Counts or Numbers.	Square Root.	Extra Mule Twist.	Mule Twist.	Weft Twist.	Twist for Doubling.	Hosiery Yarn.
1	1·00	**4·00**	**3·75**	**3·25**	**2·75**	**2·50**
2	1·41	5·65	5·30	4·60	3·88	3·53
3	1·73	6·92	6·49	5·62	4·76	4·33
4	2·00	8·00	7·50	6·50	5·50	5·00
5	2·23	8·94	8·37	7·26	6·14	5·59
6	2·44	9·79	9·18	7·96	6·73	6·12
7	2·64	10·58	9·92	8·59	7·27	6·61
8	2·82	11·31	10·50	9·19	7·77	7·07
9	3·00	12·00	11·25	9·75	8·25	7·50
10	3·16	12·64	11·85	10·27	8·79	7·90
11	3·31	13·26	12·43	10·77	9·12	8·29
12	3·46	13·85	12·99	11·25	9·52	8·66
14	3·74	14·96	14·03	12·16	10·28	9·35
16	4·00	16·00	15·00	13·00	11·00	10·00
18	4·24	16·97	15·90	13·78	11·66	10·60
20	4·47	17·88	16·77	14·53	12·29	11·18
22	4·69	18·76	17·58	15·24	12·89	......
24	4·89	19·59	18·37	15·92	13·47	......
26	5·09	20·39	19·11	16·57	14·02	......
28	5·29	21·16	19·84	17·19	14·55	......
30	5·47	21·90	20·53	17·80	15·06	......
35	5·91	23·66	22·18	19·22	16·27	......
40	6·32	25·29	23·71	20·55	17·39	......
45	6·70	26·83	25·15	21·80	18·44	......
50	7·07	28·28	26·51	22·98	19·44	......
55	7·41	29·66	27·81	24·10	20·39	......
60	7·74	30·98	29·04	25·17	21·30	......
65	8.06	32·24	30·23	26·20	22·17	......
70	8·36	33·46	31·37	27·19	23·00	......
75	8·66	34·64	32·47	28·14	23·81	......
80	8·94	35·77	33·54	29·06	24·59	......
85	9·21	36·87	34·57	29·96	25·35	......
90	9·48	37·94	35·47	30·83	26·08	......
95	9·74	38·98	36·55	31·67	26·80	......
100	10·00	40·00	37·50	32·50	27·50	......
110	10·48	41·95	39·33	34·08	28·84	......
120	10·95	43·81	41·07	35·60	30·12	......
130	11·40	45·60	42.75	37·05	31·35	......
140	11·83	47·32	44·37	38·47	32·54	......
150	12·24	48·98	45·92	39·80	33·68	......
160	12·64	50·59	47·43	41·10	34·78	......
170	13·03	52·15	48·89	42·37	35·85	......
180	13·41	53·66	50·31	43·60	36·89	......
190	13·78	55·13	51·69	44·79	37·90	......
200	14·14	56·56	53·03	45·96	38·89	......

BREAKING WEIGHT OF AMERICAN WARP YARNS, PER SKEIN.

BY GEORGE DRAPER.

Weight given in lbs. and tenths.

No.	Breaking Weight.	No.	Breaking Weight.	No.	Breaking Weight.	No.	Breaking Weight.
1		26	66·3	51	36·6	76	25·8
2		27	63·6	52	36·1	77	25·5
3	530·0	28	61·3	53	35·5	78	25·3
4	410·0	29	59·2	54	34·9	79	24·9
5	330·0	**30**	57·3	55	34·4	**80**	24·6
6	275·0	31	55·6	56	33·8	81	24·3
7	237·6	32	54·0	57	33·4	82	24·0
8	209·0	33	52·6	58	32·8	83	23·7
9	186·5	34	51·2	59	32·3	84	23·4
10	168·7	35	50·0	**60**	31·7	85	23·2
11	154·1	36	48·7	61	31·3	86	22·8
12	142·0	37	47·6	62	30·8	87	22·6
13	131·5	38	46·5	63	30·4	88	22·4
14	122·8	39	45·5	64	30·0	89	22·2
15	115·1	**40**	44·6	65	29·6	**90**	22·0
16	108·4	41	43·8	66	29·2	91	21·7
17	102·5	42	43·0	67	28·8	92	21·5
18	97·3	43	42·2	68	28·5	93	21·3
19	92·6	44	41·4	69	28·2	94	21·2
20	88·3	45	40·7	**70**	27·8	95	21·0
21	83·8	46	40·0	71	27·4	96	20·7
22	79·7	47	39·3	72	27·1	97	20·5
23	75·9	48	38·6	73	26·8	98	20·4
24	72·4	49	37·9	74	26·5	99	20·2
25	69·2	**50**	37.3	75	26·2	**100**	20·0

HYDE'S TABLE.

BREAKING WEIGHT OF ENGLISH WARP YARNS PER SKEIN.

Weight given in lbs. and tenths.

No. Yarn.	BREAKING WEIGHT.				
	Ordinary.	**Fair.**	**Good.**	**Extra.**	**Super-Extra.**
10	115·6	120·5	125·4	130·2	135·2
11	102·2	104 4	106·6	108·9	111·1
12	96·9	99·1	100·3	103·5	105·7
13	91·9	93·9	96·0	98·1	100·2
14	89·7	91 7	93·8	95·9	97·9
15	83·7	85·6	87·5	89·4	91·4
16	81·7	83·5	85·4	87·2	89·1
17	76·9	78·6	80·4	82·1	83·9
18	72 6	74·2	75·9	77·5	79·2
20	67·9	69·4	70·9	72·4	74·0
22	61·7	63·1	64·4	65·9	67·3
24	58·6	59·9	61·2	62·6	63·9
26	54·6	55·8	57·1	58·3	59·6
28	50·2	51·4	52·5	53·6	54·8
30	48·7	49·7	50·8	51·9	53·0
32	45·6	46·4	47·3	48·2	49·1
34	44·4	45·4	46·4	47·4	48·4
36	41·9	42·8	43 7	44·7	45·7
38	39·7	40·6	41·4	42·4	43·3
40	38·9	39·8	40·7	41·6	42·5
42	37·8	38·6	39·5	40·4	41·2
44	35·4	36·2	37·0	37·8	38·6
46	33·8	34·6	35·3	36·1	36 9
48	32·2	32·9	34·6	34·3	35·1
50	32·1	32·8	33·5	34·2	35 0
55	30·5	31·2	31·9	32·6	33·3
60	27·6	28·2	28·9	29·5	30·1
65	25·5	26 1	26·6	27·2	27 8
70	24·4	24·9	25·5	26·1	26 6
75	22·7	23·2	23·7	24·2	24·8
80	22·0	22·5	23·0	23·5	24·0
85	20·2	20·8	21·4	21·0	22·5
90	19·5	19·2	19·9	20·6	21·3
95	18·5	18·9	19·3	19·7	20·2
100	18·2	18·6	19·0	19·4	19·7
110	15·6	16·0	16·3	16·7	17 0
120	15·5	15·8	16·1	16·4	16·8
130	14·2	14·6	14·9	15·2	15·6
140	13·6	13·9	14·2	14·6	14·9
150	12·4	12·7	12·9	13·2	13 6

DR. BOWMAN'S TESTS OF YARN.

	Breaking Weight.	Actual Counts.
20's Mule, all American Cotton, ...	78·8	20·19
20's „ American and Egyptian Cotton, ...	102·2	19·79
20's Throstle yarn, American Cotton, ...	73·5	20·44
32's Mule yarn, American Cotton, ...	54·7	31·63
40's „ Super Bolton, Egyptian Cotton, ...	54·4	39·58
50's „ „ „ „ „ ...	35·2	50·00
60's „ „ Combed „ „ ...	33·4	58·70
40's Two-fold twined yarn, American Cotton, ...	107·4	19·14
40's „ Frame „ Egyptian „ ...	108·9	20·04
60's „ Twined „ „ „ ...	85·5	30·22
80's „ „ „ „ „ ...	61·0	38·64
120's „ Frame „ „ „ ...	51·4	59·70
120's Combed Frame „ Sea Island „ ...	63·6	59·82

The following table also by Dr. Bowman, of Halifax, England, is very interesting, as it shows clearly how far theory varies from practice, through imperfections impossible to overcome in making yarn. Eminent spinners claim the imperfections begin in the cotton fibres; as they have done everything possible to reach perfection in the operation of spinning.

COUNTS.	Average No. of Fibres in Yarn. Transverse Section.	Calculated Strength per Lea in Lbs.	Observed Strength per Lea in Lbs.	Percentage of Total Strength Utilised.	Percentage of Total Strength Lost.
20's Throstle twist American C'ton	230	388	80	20·6	79·4
32's Mule „ „ „	144	240	50	20·8	79·2
40's „ „ „ „	120	194	40	20·6	79·4
50's „ „ „ „	92	155	30	19·3	80·7
60's „ „ Egyptian „	107	156	30	19·2	80·8
30's Twofold American „	300	500	130	26·0	74·0
40's „ Egyptian „	320	450	120	26·6	73·4
50's „ „ „	240	360	96	26·6	73·4
60's „ „ „	200	300	83	27·6	72·4
80's „ „ „	160	220	60	27·2	72·8

The calculated strength was found by testing, with delicate instruments, the strength of apparently perfect single fibres of cotton; the other "Observed Strength" is the test of the whole lea in the usual way. Yarns of good quality were used.

ROVING TABLE.

FOR NUMBERING BY THE WEIGHT, IN GRAINS, OF 12 YDS.; AND SHOWING TWIST PER INCH.

Grains. Weight.	Hank Rov'g.	Sq. Root.	Twist. per in.	Grains. Weight.	Hank Rov'g.	Sq. Root.	Twist. per in.	Grains. Weight.	Hank Rov'g.	Square Root.	Twist. per in.
400·00	·25	·500	·60	147·06	·68	·825	·99	81·97	1·22	1·105	1·33
384·61	·26	·510	·61	144·93	·69	·831	1·00	80 65	1·24	1·114	1·34
370·37	·27	·520	·62	142·86	·70	·837	1 00	79·37	1·26	1·122	1·35
357·14	·28	·529	·63	140·85	·71	.843	1·01	78 12	1·28	1·131	1·36
344 83	·29	·539	·65	138 89	·72	·849	1·02	76·92	1·30	1·140	1·37
333·33	·30	·548	66	135·99	·73	·854	1 02	75·76	1·32	1·149	1·38
322·58	·31	·557	·67	135·14	·74	·860	1·03	74·63	1·34	1·158	1·39
312·50	·32	·566	·68	133·33	·75	·866	1·04	73·53	1·36	1·166	1·40
303·03	·33	·574	·69	131·58	·76	·872	1·05	72·46	1 38	1·175	1·41
294·12	·34	·583	·70	129·87	·77	·874	1·05	71·43	1·40	1·183	1·42
285·71	·35	·592	71	128·21	·78	·883	1·06	70·42	1·42	1·192	1·43
277·78	·36	·600	·72	126·58	·79	·889	1·07	69·44	1·44	1·200	1·44
270·27	·37	·608	·73	125·00	·80	·894	1 07	68·49	1·46	1·208	1·45
263·16	·38	·616	·74	123·46	·81	·900	1·08	67·57	1·48	1·217	1·46
256·41	·39	·624	·75	121·95	·82	·906	1·09	66·67	1·50	1·225	1·47
250 00	·40	·632	·76	120·48	·83	·911	1·09	65·79	1·52	1·233	1 48
243·90	·41	·640	·77	119·05	·84	·917	1·10	64 94	1·54	1·241	1·49
238·10	·42	·648	·78	117·65	·85	·922	1·11	64·10	1·56	1·249	1·50
232·56	·43	·656	·79	116·28	·86	·927	1·11	63·29	1·58	1·257	1·51
227·27	·44	·663	·80	114 94	·87	·933	1·12	62·50	1·60	1·265	1·52
222·22	·45	·671	·80	113·64	·88	·938	1·13	61·73	1·62	1·273	1·53
217·39	·46	·678	·81	112·36	·89	·943	1·13	60·98	1·64	1·281	1·54
212·77	·47	·686	·82	111·11	·90	·949	1·14	60·24	1·66	1·288	1·55
208·33	·48	·693	·83	109·89	·91	·954	1·14	59 52	1·68	1·296	1·56
204·08	·49	·700	·84	108·70	·92	·959	1·15	58·82	1·70	1·304	1 56
200 00	·50	·707	·85	107·53	·93	·964	1·16	58·14	1·72	1·311	1·57
196·08	51	·714	·86	106 38	·94	·970	1·16	57·47	1·74	1·319	1·58
192 31	·52	·721	·87	105·26	·95	·975	1·17	56·82	1·76	1·327	1·59
188·68	·53	·728	·87	104·17	·96	·980	1·18	56·18	1·78	1·334	1·60
185·19	·54	·735	·88	103·09	·97	·985	1 18	55·56	2·80	1·342	1·61
181·82	·55	·742	·89	102·04	·98	·990	1·19	54 95	1·82	1·349	1·62
178·57	·56	·748	·90	101·01	·99	·995	1·19	54·35	1·84	1·356	1·63
175·44	·57	·755	·91	100·00	1·00	1·000	1·20	53·76	1·86	1·364	1·64
172·41	·58	·762	·91	98·04	1·02	1·010	1·21	53·19	1·88	1·371	1·65
169·49	·59	·768	·92	96·15	1·04	1 020	1·22	52·63	1·90	1·378	1·65
166 67	·60	·775	·93	94·34	1·06	1·030	1·24	52·08	1·92	1·386	1·66
163·93	·61	·781	·94	92·59	1·08	1·039	1 25	51·55	1·94	1·393	1·67
161·29	·62	·787	·94	90·91	1·10	1·049	1·26	51·02	1·96	1·400	1·68
158·73	·63	·794	·95	89·29	1·12	1·058	1 27	50·51	1·98	1·407	1·69
156 25	·64	·800	·96	87·72	1 14	1·068	1·28	50 00	2 00	1·414	1·70
153·85	·65	·806	·97	86·21	1·16	1·077	1·29	49 50	2·02	1·421	1·71
15152	66	·812	·97	84·75	1 18	1·086	1·30	49·02	2·04	1·428	1·71
149·25	·67	·819	·98	83·33	1·20	1·095	1·31	48·54	2·06	1·435	1·72

ROVING TABLE.—Continued.

FOR NUMBERING BY THE WEIGHT, IN GRAINS, OF 12 YDS.; AND SHOWING TWIST PER INCH.

Grains. Weight.	Hank Rov'g.	Sq. Root.	Twist per in.	Grains. Weight.	Hank Rov'g.	Sq. Root.	Twist per in.	Grains Wght.	Hank Rov'g.	Sq. Root.	Twist per in.
48·08	2·08	1·442	1·73	34·01	2·94	1·715	2.06	14·29	7·00	2·646	3·17
47·62	2·10	1·449	1·74	33·78	2·96	1·721	2·07	14·08	7·10	2·665	3·20
47·17	2·12	1·456	1·75	33·56	2·98	1·726	2·07	13·89	7·20	2·683	3·22
46.73	2·14	1·463	1·76	33·33	3·00	1·732	2·08	13·70	7·30	2·702	3·24
46·30	2·16	1·470	1·76	32·26	3·10	1·761	2·11	13·51	7·40	2·720	3·26
45·87	2·18	1·476	1·77	31·25	3·20	1·789	2·15	13·33	7·50	2·739	3·29
45·45	2·20	1·483	1·78	30·30	3·30	1·817	2·18	13·16	7·60	2·757	3·31
45·05	2·22	1·490	1·79	29·41	3·40	1·844	2·21	12·99	7·70	2·775	3·33
44·64	2·24	1·497	1·80	28·57	3·50	1·871	2·24	12·82	7·80	2·793	3·35
44·25	2·26	1·503	1·80	27·78	3·60	1·897	2·28	12·66	7·90	2·811	3·37
43·86	2·28	1·510	1·81	27·03	3·70	1·924	2·31	12·50	8·00	2·828	3·39
43·48	2·30	1·517	1·82	26·32	3·80	1·949	2·34	12·35	8·10	2·846	3·42
43·10	2·32	1·523	1·83	25·64	3·90	1·975	2·37	12·20	8·20	2·864	3·44
42·74	2·34	1·530	1·84	25·00	4·00	2·000	2·40	12·05	8·30	2·881	3·46
42·37	2·36	1·536	1·84	24·39	4·10	2·025	2·43	11·90	8.40	2·898	3·48
42·02	2·38	1·543	1·85	23·81	4·20	2·049	2·46	11·76	8·50	2·915	3·50
41·67	2·40	1·549	1·86	23·26	4·30	2·074	2·49	11·63	8·60	2·933	3·52
41·32	2·42	1·556	1·87	22·73	4·40	2·098	2·52	11·49	8·70	2·950	3·54
40·98	2·44	1·562	1·87	22·22	4·50	2·121	2·55	11·36	8·80	2·966	3·56
40·65	2·46	1·568	1·88	21·74	4·60	2·145	2·57	11·24	8·90	2·983	3·58
40·32	2·48	1·575	1·89	21·28	4·70	2·168	2·60	11·11	9·00	3·000	3·60
40·00	2·50	1·581	1·90	20·83	4·80	2·191	2·63	10·99	9·10	3·017	3·62
39·68	2·52	1·587	1·90	20·41	4·90	2·214	2·66	10·87	9·20	3·033	3·64
39·37	2·54	1·594	1·91	20·00	5·00	2·236	2·68	10·75	9·30	3·050	3·66
39·06	2·56	1·600	1·92	19·61	5·10	2·258	2·71	10·64	9·40	3·066	3·68
38·76	2·58	1·606	1·93	19·23	5·20	2·280	2·74	10·53	9·50	3·082	3·70
38·46	2·60	1·612	1·93	18·87	5·30	2·302	2·76	10.42	9·60	3·098	3·72
38·17	2·62	1·619	1·94	18·52	5·40	2·324	2·79	10·31	9·70	3·114	3·74
37·88	2·64	1·625	1·95	18·18	5·50	2·345	2·81	10·20	9·80	3·130	3·76
37·59	2·66	1·631	1·96	17·86	5·60	2·366	2·84	10·10	9·90	3·146	3·78
37·31	2·68	1·637	1·96	17·54	5·70	2·387	2·86	10·00	10·00	3·162	3·79
37·04	2·70	1·643	1·97	17·24	5·80	2·408	2·89	9·09	11·00	3·317	3·98
36·76	2·72	1·649	1·98	16·95	5·90	2·429	2·91	8·33	12·00	3·464	4·16
36·50	2·74	1·655	1·99	16·67	6·00	2·449	2·94	7·69	13·00	3·606	4·33
36·23	2·76	1·661	1·99	16·39	6·10	2·470	2·96	7·14	14·00	3·742	4·49
35·97	2·78	1·667	2·00	16·13	6·20	2·490	2·99	6·67	15·00	3·873	4·65
35·71	2·80	1·673	2·01	15·87	6·30	2·510	3·01	6·25	16·00	4·000	4·80
35·46	2·82	1·679	2·01	15·62	6·40	2·530	3·04	5·88	17·00	4·123	4·95
35·21	2·84	1·685	2·02	15·38	6·50	2·550	3·06	5·56	18·00	4·243	5·09
34·97	2.86	1·691	2·03	15·15	6·60	2·569	3·08	5·26	19·00	4·359	5·23
34·72	2·88	1·697	2·04	14·93	6·70	2·588	3·11	5·00	20·00	4.472	5·37
34·48	2·90	1·703	2·04	14·71	6·80	2·608	3·13				
34·25	2·92	1·709	2·05	14·49	6·90	2·627	3·15				

YARN TABLE.

FOR NUMBERING COTTON YARN BY THE WEIGHT IN GRAINS OF 120 YDS. OR 1 SKEIN.

120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.
1·	1000·	13·	76·92	19·	52·63	25·	40·00	31·	32·26	37·	27·03	43·	23·26	49·	20·41
2.	500·	·1	76·34	·1	52·36	·1	39·84	·1	32·16	·1	26·95	·1	23·20	·1	20·37
3·	333·3	·2	75·76	·2	52·08	·2	39·68	·2	32·05	·2	26·88	·2	23·15	·2	20·33
4·	250·0	·3	75·19	·3	51·81	·3	39·53	·3	31·95	·3	26·81	·3	23·09	·3	20·28
5·	200·0	·4	74·63	·4	51·55	·4	39·37	·4	31·85	·4	26·74	·4	23·04	·4	20·24
5·5	181·8	·5	74·07	·5	51·28	·5	39·22	·5	31·75	·5	26·67	·5	22·99	·5	20·20
6·	166·7	·6	73·53	·6	51·02	·6	39·06	·6	31·65	·6	26·60	·6	22·94	·6	20·16
6·5	153·8	·7	72·99	·7	50·76	·7	38·91	·7	31·55	·7	26·53	·7	22·88	·7	20·12
7·	142·9	·8	72·46	·8	50·51	·8	38·76	·8	31·45	·8	26·46	·8	22·83	·8	20·08
7·5	133·3	·9	71·94	·9	50·25	·9	38·61	·9	31·35	·9	26·39	·9	22·78	·9	20·04
8·	125·0	14·	71·43	20·	50·00	26·	38·46	32·	31·25	38·	26·32	44·	22·73	50·	20·00
·1	123·5	·1	70·92	1·	49·75	·1	38·31	·1	31·15	·1	26·25	·1	22·68	·1	19·96
·2	122·0	·2	70·42	2·	49·50	·2	38·17	·2	31·06	·2	26·18	·2	22·62	·2	19·92
·3	120·5	·3	69·93	3·	49·26	·3	38·02	·3	30·96	·3	26·11	·3	22·57	·3	19·88
·4	119·0	·4	69·44	4·	49·02	·4	37·88	·4	30·86	·4	26·04	·4	22·52	·4	19·84
·5	117·6	·5	68·97	5·	48·78	·5	37·74	·5	30·77	·5	25·97	·5	22·47	·5	19·80
·6	116·3	·6	68·49	6·	48·54	·6	37·59	·6	30·67	·6	25·91	·6	22·42	·6	19·76
·7	114·9	·7	68·03	7·	48·31	·7	37·45	·7	30·58	·7	25·84	·7	22·37	·7	19·72
·8	113·6	·8	67·57	8·	48·08	·8	37·31	·8	30·49	·8	25·77	·8	22·32	·8	19·69
·9	112·4	·9	67·11	9·	47·85	·9	37·17	·9	30·40	·9	25·71	·9	22·27	·9	19·65
9·	111·1	15·	66·67	21·	47·62	27·	37·04	33·	30·30	39·	25·64	45.	22·22	51·	19·61
·1	109·9	·1	66·23	·1	47·39	1·	36·90	·1	30·21	·1	25·58	·1	22·17	·1	19·57
·2	108·7	·2	65·79	·2	47·17	2·	36.77	·2	30·12	·2	25·51	·2	22·12	·2	19·53
·3	107·5	·3	65·36	·3	46·95	3·	36·63	·3	30·03	·3	25·45	·3	22·08	·3	19·49
·4	106·4	·4	64·94	·4	46·73	4·	36·50	·4	29·94	·4	25·38	·4	22·03	·4	19·46
·5	105·3	·5	64·52	·5	46·51	5·	36·36	·5	29·85	·5	25·32	·5	21·98	·5	19·42
·6	104·2	·6	64·10	·6	46·30	6·	36·23	·6	29·76	·6	25·25	·6	21·93	·6	19·38
·7	103·1	·7	63·69	·7	46·08	7·	36·10	·7	29·67	·7	25·19	·7	21·88	·7	19·34
·8	102·0	·8	63·29	·8	45·87	8·	35·97	·8	29·59	·8	25·13	·8	21·83	·8	19·31
·9	101·0	·9	62·89	·9	45·66	9·	35·84	·9	29·50	·9	25·06	·9	21·79	·9	19·27
10·	100·0	16·	62·50	22·	45·45	28·	35·71	34·	29·41	40·	25·00	46·	21·74	52·	19·23
·1	99·01	·1	62·11	·1	45·25	·1	35·59	·1	29·33	·1	24·94	·1	21·69	·1	19·19
·2	98·04	·2	61·73	·2	45·05	·2	35·46	·2	29·24	·2	24·88	·2	21·65	·2	19·16
·3	97·09	·3	61·35	·3	44·84	·3	35·34	·3	29·15	·3	24·81	·3	21·60	·3	19·12
·4	96·15	·4	60·98	·4	44·64	·4	35·21	·4	29·07	·4	24·75	·4	21·55	·4	19·08
·5	95·24	·5	60·61	·5	44·44	·5	35·09	·5	28·99	·5	24·69	·5	21·51	·5	19·05
·6	94·34	·6	60·24	·6	44·25	·6	34·97	·6	28·90	·6	24·63	·6	21·46	·6	19·01
·7	93·46	·7	59·88	·7	44·05	·7	34·84	·7	28·82	·7	24·57	·7	21·41	·7	18·98
·8	92·59	·8	59·52	·8	43·86	·8	34·72	·8	28·74	·8	24·51	·8	21·37	·8	18·94
·9	91·74	·9	59·17	·9	43·67	·9	34·60	·9	28·65	·9	24·45	·9	21·32	·9	18·90
11·	90·91	17·	58·82	23·	43·48	29·	34·48	35·	28·57	41·	24·39	47·	21·28	53·	18·87
·1	90·09	·1	58·48	·1	43·29	·1	34·36	·1	28·49	·1	24·33	·1	21·23	·1	18·83
·2	89·29	·2	58·14	·2	43·10	·2	34·25	·2	28·41	·2	24·27	·2	21·19	·2	18·80
·3	88·50	·3	57·80	·3	42·92	·3	34·13	·3	28·33	·3	24·21	·3	21·14	·3	18·76
·4	87·72	·4	57·47	·4	42·74	·4	34·01	·4	28·25	·4	24·15	·4	21·10	·4	18·73
·5	86·96	·5	57·14	·5	42·55	·5	33·90	·5	28·17	·5	24·10	·5	21·05	·5	18·69
·6	86·21	·6	56·82	·6	42·37	·6	33·78	·6	28·09	·6	24·04	·6	21·01	·6	18·66
·7	85·47	·7	56·50	·7	42·19	·7	33·67	·7	28·01	·7	23·98	·7	20·96	·7	18·62
·8	84·75	·8	56·18	·8	42·02	·8	33·56	·8	27·93	·8	23·92	·8	20·92	·8	18·59
·9	84·03	·9	55·87	·9	41·84	·9	33·44	·9	27·86	·9	23·87	·9	20·88	·9	18·55
12·	83·33	18·	55·56	24·	41·67	30·	33·33	36·	27·78	42·	23·81	48·	20·83	54·	18·52
·1	82·64	·1	55·25	·1	41·49	·1	33·22	·1	27·70	·1	23·75	·1	20·79	·1	18·48
·2	81·97	·2	54·95	·2	41·32	·2	33·11	·2	27·62	·2	23·70	·2	20·75	·2	18·45
·3	81·30	·3	54·64	·3	41·15	·3	33·00	·3	27·55	·3	23·64	·3	20·70	·3	18·42
·4	80·65	·4	54·35	·4	40·98	·4	32·89	·4	27·47	·4	23·58	·4	20·66	·4	18·38
·5	80·00	·5	54·05	·5	40·82	·5	32·79	·5	27·40	·5	23·53	·5	20·62	·5	18·35
·6	79·37	·6	53·76	·6	40·65	·6	32·68	·6	27·32	·6	23·47	·6	20·57	·6	18·32
·7	78·74	·7	53·48	·7	40·49	·7	32·57	·7	27·25	·7	23·42	·7	20·53	·7	18·28
·8	78·12	·8	53·19	·8	40·32	·8	32·47	·8	27·17	·8	23·36	·8	20·49	·8	18·25
·9	*77·52*	*·9*	*52·91*	·9	40·16	·9	32·36	·9	27·10	·9	23·31	·9	20·45	·9	18·21

YARN TABLE.—Continued.

FOR NUMBERING COTTON YARN BY THE WEIGHT IN GRAINS OF 120 YDS. OR 1 SKEIN.

120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.
55·	18·18	61·	16·39	67·	14·93	73·	13·70	79·	12·66	85·	11·76	91·	10·99	97·	10·31
·1	18·15	·1	16·37	·1	14·90	·1	13·68	·1	12·64	·1	11·75	·1	10·98	·1	10·30
·2	18·12	·2	16·34	·2	14·88	·2	13·66	·2	12·63	·2	11·74	·2	10·96	·2	10·29
·3	18·08	·3	16·31	·3	14·86	·3	13·64	·3	12·61	·3	11·72	·3	10·95	·3	10·28
·4	18·05	·4	16·29	·4	14·84	·4	13·62	·4	12·59	·4	11·71	·4	10·94	·4	10·27
·5	18·02	·5	16·26	·5	14·81	·5	13·61	·5	12·58	·5	11·70	·5	10·93	·5	10·26
·6	17·99	·6	16·23	·6	14·79	·6	13·59	·6	12·56	·6	11·68	·6	10·92	·6	10·25
·7	17·95	·7	16·21	·7	14·77	·7	13·57	·7	12·55	·7	11·67	·7	10·91	·7	10·24
·8	17·92	·8	16·19	·8	14·75	·8	13·55	·8	12·53	·8	11·66	·8	10·89	·8	10·22
·9	17·89	·9	16·16	·9	14·73	·9	13·53	·9	12·52	·9	11·64	·9	10·88	·9	10.21
56·	17·86	62·	16·13	68·	14·71	74·	13·51	80·	12.50	86·	11·63	92·	10·87	98·	10·20
·1	17·83	·1	16·10	·1	14·68	·1	13·50	·1	12·48	·1	11·61	·1	10·86	·1	10·19
·2	17·79	·2	16·08	·2	14·66	·2	13·48	·2	12·47	·2	11·60	·2	10·85	·2	10·18
·3	17·76	·3	16·05	·3	14·64	·3	13·46	·3	12·45	·3	11·59	·3	10·83	·3	10·17
·4	17·73	·4	16·03	·4	14·62	·4	13·44	·4	12·44	·4	11·57	·4	10·82	·4	10·16
·5	17·70	·5	16·00	·5	14·60	·5	13·42	·5	12·42	·5	11·56	·5	10·81	·5	10·15
·6	17·67	·6	15·97	·6	14·58	·6	13·40	·6	12·41	·6	11·55	·6	10·80	·6	10·14
·7	17·64	·7	15·95	·7	14·56	·7	13·39	·7	12·39	·7	11·53	·7	10·79	·7	10·13
·8	17·61	·8	15·92	·8	14·53	·8	13·37	·8	12·38	·8	11·52	·8	10·78	·8	10·12
·9	17·57	·9	15·90	·9	14·51	·9	13·35	·9	12·36	·9	11·51	·9	10·76	·9	10·11
57·	17·54	63·	15·87	69·	14·49	75·	13·33	81·	12·35	87·	11·49	93·	10·75	99·	10·10
·1	17·51	·1	15·85	·1	14·47	·1	13·32	·1	12·33	·1	11·48	·1	10·74	·1	10·09
·2	17·48	·2	15·83	·2	14·45	·2	13·30	·2	12·32	·2	11·47	·2	10·73	·2	10·08
·3	17·45	·3	15·80	·3	14·43	·3	13·28	·3	12·30	·3	11·45	·3	10·72	·3	10·07
·4	17·42	·4	15·77	·4	14·41	·4	13·26	·4	12·29	·4	11·44	.4	10·71	·4	10·06
·5	17·39	·5	15·75	·5	14·39	·5	13·25	·5	12·27	·5	11·43	·5	10·70	·5	10·05
·6	17·36	·6	15·72	·6	14·37	·6	13·23	·6	12·25	·6	11·42	·6	10·68	·6	10·04
·7	17·33	·7	15·70	·7	14·35	·7	13·21	·7	12·24	·7	11·40	·7	10·67	·7	10·03
·8	17·30	·8	15·67	·8	14·33	·8	13·19	·8	12·22	·8	11·59	·8	10·66	·8	10·02
·9	17·27	·9	15·65	·9	14·31	·9	13·18	·9	12·21	·9	11·38	·9	10·65	·9	10·01
58·	17·24	64·	15·62	70·	14·29	76·	13·16	82·	12·20	88·	11·36	94·	10·64	100·	10·00
·1	17·21	·1	15·60	·1	14·27	·1	13·14	·1	12·18	·1	11·35	·1	10·63	·1	9·99
·2	17·18	·2	15·58	·2	14·25	·2	13·12	·2	12·17	·2	11·34	·2	10·62	·2	9·98
·3	17·15	·3	15·55	·3	14·22	·3	13·11	·3	12·15	·3	11·33	·3	10·60	·3	9·97
·4	17·12	·4	15·53	·4	14·20	·4	13·09	·4	12·14	·4	11·31	·4	10·59	·4	9·96
·5	17·09	·5	15·50	·5	14·18	·5	13·07	·5	12·12	·5	11·30	·5	10·58	·5	9·95
·6	17·06	·6	15·48	·6	14·16	·6	13·05	·6	12·11	·6	11·29	·6	10·57	·6	9·94
·7	17·04	·7	15·46	·7	14·14	·7	13·04	·7	12·09	·7	11·27	·7	10·56	·7	9·93
·8	17·01	·8	15·43	·8	14·12	·8	13·02	·8	12·08	·8	11·26	·8	10·55	·8	9·92
·9	16·98	·9	15·41	·9	14·10	·9	13·00	·9	12·06	·9	11·25	·9	10·54	.9	9·91
59·	16·95	65·	15·38	71·	14·08	77·	12·99	83·	12·05	89·	11·24	95·	10·53	101·	9·90
·1	16·92	·1	15·36	·1	14·06	·1	12·97	·1	12·03	·1	11·22	·1	10·52	·1	9·89
·2	16·89	·2	15·34	·2	14·04	·2	12·95	·2	12·02	·2	11·21	·2	10·50	·2	9·88
·3	16·86	·3	15·31	·3	14·03	·3	12·94	·3	12·00	·3	11·20	·3	10·49	·3	9·87
·4	16·84	·4	15·29	·4	14·01	·4	12·92	·4	11·99	·4	11·19	·4	10·48	·4	9·86
·5	16·81	·5	15·27	·5	13·99	·5	12·90	·5	11·98	·5	11·17	·5	10·47	·5	9.85
·6	16·78	·6	15·24	·6	13·97	·6	12·89	·6	11·96	·6	11·16	·6	10·46	·6	9·84
·7	16·75	·7	15·22	·7	13·95	·7	12·87	·7	11·95	·7	11·15	·7	10·45	·7	9·83
·8	16·72	·8	15·20	·8	13·93	·8	12·85	·8	11·93	·8	11·14	·8	10·44	·8	9·82
·9	16·69	·9	15·17	·9	13·91	·9	12·84	·9	11·92	·9	11·12	·9	10·43	·9	9·81
60·	16·67	66·	15·15	72·	13·89	78·	12·82	84·	11·90	90·	11·11	96·	10·42	102·	9·80
·1	16·64	·1	15·13	·1	13·87	·1	12·80	1·	11·89	·1	11·10	·1	10·41	·1	9·79
·2	16·61	·2	15·11	·2	13·85	·2	12·79	2·	11·88	·2	11·09	·2	10·40	·2	9·78
·3	16·58	·3	15·08	·3	13·83	·3	12·77	3·	11·86	·3	11·07	·3	10·38	·3	9·78
·4	16·56	·4	15·06	·4	13·81	·4	12·76	4·	11·85	·4	11·06	·4	10·37	·4	9·77
·5	16·53	·5	15·04	·5	13·79	·5	12·74	5·	11·83	·5	11·05	·5	10·36	·5	9·76
·6	16·50	·6	15·02	·6	13·77	·6	12·72	6·	11·82	·6	11·04	·6	10·35	·6	9·75
·7	16·47	·7	14·99	·7	13·76	·7	12·71	7·	11·81	·7	11·03	·7	10·34	·7	9·74
·8	16·45	·8	14·97	·8	13·74	·8	12·69	8·	11·79	·8	11·01	·8	10·33	·8	9·73
·9	16·42	·9	14·95	·9	13·72	·9	12·67	9·	11·78	·9	11·00	·9	10·32	·9	9·72

YARN TABLE.—Continued.

FOR NUMBERING COTTON YARN BY THE WEIGHT IN GRAINS OF 120 YARDS OR 1 SKEIN.

120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 Yds. weigh Grs.	Number of Yarn.	120 yards weigh Grs.	Number of Yarn.
103·	9·71	·5	9·22	119·	8·40	·5	7·02	170·	5·88	225·	4·44	310·	3·23	475·	2·11
·1	9·70	·6	9·21	·2	8·39	143·	6·99	171·	5·85	226·	4·42	312·	3·21	480·	2·08
·2	9·69	·7	9·20	·4	8·38	·5	6·97	172·	5·81	227·	4·41	314·	3·18	485·	2·06
·3	9·68	·8	9·19	·6	8·36	144·	6·94	173·	5·78	228·	4·39	316·	3·17	490·	2·04
·4	9·67	·9	9·18	·8	8·35	·5	6·92	174·	5·75	229·	4·37	318·	3·14	495·	2·02
·5	9·66	109·	9·17	120·	8·33	145·	6·90	175·	5·71	230·	4·35	320·	3·12	500·	2·00
·6	9·65	·2	9·16	·2	8·32	·5	6·87	176·	5·68	231·	4·33	322·	3·11	505·	1·98
·7	9·64	·4	9·14	·4	8·31	146·	6·85	177·	5·65	232·	4·31	324·	3·09	510·	1·96
·8	9·63	·6	9·12	.6	8·29	·5	6·83	178·	5·62	233·	4·29	326·	3·07	515·	1·94
·9	9·62	·8	9·11	·8	8·28	147·	6·80	179·	5·59	234·	4·27	328·	3·05	520·	1·92
104·	9·62	110·	9·09	121·	8·26	·5	6·78	180·	5·56	235·	4·26	330·	3·03	525·	1·90
·1	9·61	·2	9·07	·4	2·24	148·	6·76	181·	5.52	236·	4·24	332·	3·01	530·	1·89
·2	9·60	·4	9·06	·6	8·22	·5	6·73	182·	5.49	237·	4·22	334·	2·99	535·	1·87
·3	9·59	·6	9·04	·8	8·21	149·	6·71	183·	5.46	238·	4·20	336·	2·98	540·	1·85
·4	9·58	·8	9·03	122·	8·20	·5	6·69	184·	5.43	239·	4·18	338·	2·96	545·	1·83
·5	9·57	111·	9·01	·5	8·16	150·	6·67	185·	5.41	240·	4·17	340·	2·94	550·	1·82
·6	9·56	·2	8·99	123·	8·13	·5	6·64	186·	5.38	241·	4·15	342·	2·92	555·	1·80
·7	9·55	·4	8·98	·5	8·10	151·	6·62	187·	5.35	242·	4·13	344·	2·91	560·	1·79
·8	9·54	·6	8·96	124·	8·06	·5	6·60	188·	5.32	243·	4·12	346·	2·89	565·	1·77
·9	9·53	·8	8·94	·5	8·03	152·	6·58	189·	5.29	244·	4·10	348·	2·87	570·	1·75
105·	9·52	112·	8·93	125·	8·00	·5	6·56	190·	5.26	245·	4·08	350·	2·86	575·	1·74
·1	9·51	·2	8·91	·5	7·97	153·	6·54	191·	5.24	246·	4·07	352·	2·84	580·	1·72
·2	9·51	·4	8·90	126·	7·94	·5	6·51	192·	5.21	247·	4·05	354·	2·82	585·	1·71
·3	9·50	·6	8·88	·5	7·91	154·	6·49	193·	5.18	248·	4·03	356·	2·81	590·	1·69
·4	9·49	·8	8·87	127·	7·87	·5	6·47	194·	5.15	249·	4·02	358·	2·79	595·	1·68
·5	9·48	113·	8·85	·5	7·84	155·	6·45	195·	5.13	250·	4·00	360·	2·78	600·	1·87
·6	9·47	·2	8·83	128·	7·81	·5	6·43	196·	5.10	252·	3·97	362·	2·76	610·	1·64
·7	9·46	·4	8·82	·5	7·78	156·	6·41	197·	5.08	254·	3·94	364·	2·75	620·	1·61
·8	9·45	·6	8·80	129·	7·75	·5	6·39	198·	5.05	256·	3·91	366·	2·73	630·	1·59
·9	9·44	·8	8·79	·5	7·72	157·	6·37	199·	5.03	258·	3·88	368·	2·72	640·	1·56
106·	9·43	114·	8·77	130·	7·69	·5	6·35	200·	5.00	260·	3·85	370·	2·70	650·	1·54
·1	9·43	·2	8·76	·5	7·66	158·	6·33	201·	4·98	262·	3·82	372·	2·69	660·	1·52
·2	9·42	·4	8·74	131·	7·63	·5	6·31	202·	4·95	264·	3·79	374·	2·67	670·	1·49
·3	9·41	·6	8·73	·5	7·60	159·	6·29	203·	4·93	266·	3·76	376·	2·66	680·	1·47
·4	9·40	·8	8·71	132·	7·58	·5	6·27	204·	4·90	268·	3·73	378·	2·65	690·	1·45
·5	9·39	115·	8·70	·5	7·55	160·	6·25	205·	4·88	270·	3·70	380·	2·63	700·	1·43
·6	9·38	·2	8·68	133·	7·52	·5	6·23	206·	4·85	272·	3·68	382·	2·62	710·	1·41
·7	9·37	·4	8·67	·5	7·49	161·	6·21	207·	4·83	274·	3·65	385·	2·60	720·	1·39
·8	9·36	·6	8·65	134·	7·46	·5	6·19	208·	4·81	276·	3·62	390·	2·56	730·	1·37
·9	9·35	·8	8·64	·5	7·43	162·	6·17	209·	4·78	278·	3·60	395·	2·53	740·	1·35
107·	9·35	116·	8·62	135·	7·41	·5	6·15	210·	4·76	280·	3·57	400·	2·50	750·	1·33
·1	9·34	·2	8·61	·5	7·38	163·	6·13	211·	4·74	282·	3·55	405·	2·47	760·	1·32
·2	9·33	·4	8·59	136·	7·35	·5	6·12	212·	4·72	284·	3·52	410·	2·44	770·	1·30
·3	9·32	·6	8·58	·5	7·33	164·	6·10	213·	4·69	286·	3·50	415·	2·41	780·	1·28
·4	9·31	·8	8·56	137·	7·30	·5	6·08	214·	4·67	288·	3·47	420·	2·38	790·	1·27
·5	9·30	117·	8·55	·5	7·27	165·	6·06	215·	4·65	290·	3·45	425·	2·35	800·	1·25
·6	9·29	·2	8·53	138·	7·25	·5	6·04	216·	4·63	292·	3·42	430·	2·33	820·	1·22
·7	9·29	·4	8·52	·5	7·22	166·	6·02	517·	4·61	294·	3·40	435·	2·30	840·	1·19
·8	9·28	·6	8·50	139·	7·19	·5	6·01	218·	4·59	296·	3·38	440·	2·27	860·	1·16
·9	9·27	·8	8·49	·5	7·17	167·	5·99	219·	4·57	298·	3·36	445·	2·25	880·	1·14
108·	9·26	118·	8·47	140·	7·14	·5	5·97	220·	4·55	300·	3·33	450·	2·22	900·	1·11
·1	9·25	·2	8·46	·5	7·12	168·	5·95	221·	4·52	302·	3·31	455·	2·20	925·	1·08
·2	9·24	·4	8·45	141·	7.09	·5	5·93	222·	4·50	304·	3·29	460·	2·17	950·	1·05
·3	9·23	·6	8·43	·5	7·07	169·	5·92	223·	4·48	306·	3·27	465·	2·15	975·	1·03
·4	9·23	·8	8·42	142.	7·04	·5	5·90	224·	4·46	308·	3·25	470·	2·13	1000·	1·00

YARN TABLE.

FOR NUMBERING COTTON YARN BY THE WEIGHT IN GRAINS, OF 840 YARDS, OR ONE HANK.

Number of Yarn.	Grains per Hank.	Number of Yarn.	Grains per Hank.	Number of Yarn.	Grains per Hank.	Number of Yarn.	Grains per Hank.	Number of Yarn.	Grains per Hank.	Number of Yarn.	Grains per Hank.
9	777·78	20	350 00	31	225·81	42	166·67	53	132·08	76	92·1
9¼	756·76	20¼	345·68	31¼	224·00	42¼	165·68	53¼	131·46	77	90·9
9½	736·84	20½	341·46	31½	222 22	42½	164·71	53½	130·84	78	89·7
9¾	717·95	20¾	337·35	31¾	220·47	42¾	163·74	53¾	130·23	79	88·6
10	700 00	21	333·33	32	218·75	43	162·79	54	129·63	80	87·5
10¼	682 93	21¼	329·41	32¼	217·05	43¼	161·85	54¼	129 03	81	86·4
10½	666·67	21½	325·58	32½	215·38	43½	160 92	54½	128·44	82	85·4
10¾	651·16	21¾	321·84	32¾	213·74	43¾	160·00	54¾	127·85	83	84·3
11	636·36	22	318·18	33	212·12	44	159·09	55	127·27	84	83·3
11¼	622·22	22¼	314 61	33¼	210·52	44¼	158·19	55¼	126·70	85	82·4
11½	608·70	22½	311·11	33½	208·96	44½	157·30	55½	126·13	86	81·4
11¾	595·74	22¾	307·69	33¾	207·41	44¾	156 42	55¾	125·56	87	80·5
12	583·33	23	304·35	34	205·88	45	155·56	56	125·00	88	79·5
12¼	571·43	23¼	301 08	34¼	204 38	45¼	154·70	56¼	124·44	89	78·7
12½	560·00	23½	297·87	34½	202·90	45½	153·85	56½	123·89	90	77·8
12¾	549 02	23¾	294·74	34¾	201·44	45¾	153·01	56¾	123·35	91	76·9
13	538·46	24	291·67	35	200·00	46	152·17	57	122·81	92	76·1
13¼	528·30	24¼	288·66	35¼	198·58	46¼	151·35	57¼	122·27	93	75·3
13½	518·52	24½	285 71	35½	197·18	46½	150·54	57½	121·74	94	74·5
13¾	509 09	24¾	282·83	35¾	195·80	46¾	149·73	57¾	121·21	95	73·7
14	500 00	25	280·00	36	194·44	47	148·94	58	120·69	96	72·9
14¼	491·23	25¼	277·23	36¼	193·10	47¼	148·15	58¼	120·17	97	72·2
14½	482·76	25½	274·51	36½	191·78	47½	147·37	58½	119·66	98	71·4
14¾	474·58	25¾	271·84	36¾	190·48	47¾	146·60	58¾	119·15	99	70·7
15	466·67	26	269·23	37	189·19	48	145·83	59	118·64	100	70 0
15¼	459·02	26¼	266·67	37¼	187·92	48¼	145·08	59¼	118·14	105	66·7
15½	451·61	26½	264·15	37½	186·67	48½	144·33	59½	117·64	110	63·6
15¾	444·44	26¾	261·68	37¾	185·43	48¾	143 59	59¾	117·15	115	60 9
16	437·50	27	259·26	38	184·21	49	142·86	60	115 67	120	58·3
16¼	430·77	27¼	256·88	38¼	183 01	49¼	142·13	61	114·8	125	56 0
16½	424·24	27½	254 55	38½	181·82	49½	141·41	62	112·9	130	53·8
16¾	417·91	27¾	252·25	38¾	180·65	49¾	140·70	63	111·1	135	51·9
17	411·76	28	250·00	39	179·49	50	140·00	64	109·4	140	50·0
17¼	405·80	28¼	247·79	39¼	178·35	50¼	139·30	65	107·7	145	48·3
17½	400·00	28½	245·61	39½	177·21	50½	138·61	66	106·1	150	46·7
17¾	394·37	28¾	243·48	39¾	176·10	50¾	137·93	67	104·5	155	45·2
18	388·89	29	241·38	40	175·00	51	137·25	68	102·9	160	43·7
18¼	383·56	29¼	239·32	40¼	173·91	51¼	136·59	69	101·4	165	42·4
18½	378·38	29½	237·29	40½	172·84	51½	135·92	70	100·0	170	41·2
18¾	373·33	29¾	235·29	40¾	171·78	51¾	135·27	71	98·6	175	40 0
19	368·42	30	233·33	41	170 73	52	134·62	72	97·2	180	38·9
19¼	363·64	30¼	231·40	41¼	169·70	52¼	133·97	73	95 9	185	37·8
19½	358·97	30½	229·51	41½	168·67	52½	133·33	74	94·6	190	36·8
19¾	354·43	30¾	227·64	41¾	167·66	52¾	132·70	75	93 3	195	35·9
										100	35·0

THE MANUFACTURE OF FINE YARNS AND SPECIALITIES.

The fine spinning branch of the cotton spinning industry may very appropriately and correctly be described as one of the fine arts. It is in the manufacture of fine yarns, and of high grade specialities, that special and particular skill and knowledge is required; more especially so is this the case in the manufacture of yarns from long stapled Sea Islands cottons. Sea Islands—Florida and Fiji—cottons are the finest and most delicate varieties grown. The fineness to which these cottons are drawn out in fine spinning, producing yarns of the most delicate texture, requires therefore the most delicate and careful treatment during the progress from cotton to yarn.

To make a commercial and practical success of fine spinning, scientific skill, combined with knowledge and judgment of the requirements and conditions surrounding this particular branch of the art, are absolutely essential elements necessary to success.

In France and England fine spinning and the production of high grade yarns for special purposes has long been successfully carried on, and in the United States of America fine yarns and specialties are to-day being equally well and successfully spun in many of the leading mills. France is of course noted for its very fine spinning; and even in Russia, where the conditions are probably more unfavourable than in either America, England, or any other European country, they now spin 100's and finer with comparative ease and success. Given the three leading or fundamental factors, good machinery, good cotton, and good help, which are nowadays accessible to all alike in both Europe and America, and equal results are attainable all round.

The superiority of one manufacturer of superior and high-class yarns over another is due to the greater care and attention bestowed upon the manipulation of the material by the one than the other; to his superior arrangements for securing cleanliness, to attention to every detail, to his continual watching and controlling of both the machinery and the material. Also to intelligent and skilful management of labour, and to scientific laying out of the machinery so as to produce the best results possible in both quantity, quality, and economy.

The foregoing and the following pages on "Machinery," "Particulars," and "Calculations," have, as will be seen, special reference to the manufacture of fine and good quality yarns, and the data and information here given may be taken as a basis upon which to proceed in the spinning of fine yarns.

These chapters moreover, bearing upon the technical treatment of the subject of cotton spinning, have been written from actual existing conditions; conditions existing to-day in one of the foremost and leading fine-spinning mills of the world.

MACHINERY FOR PREPARING AND SPINNING 60'S AND 100'S TWIST YARN FROM SEA ISLANDS COTTON FOR SEWING THREAD, WITH PARTICULARS OF SPEEDS OF SPINDLES, FRONT ROLLER, PRODUCTION, ETC.

For the lower counts, such as 60's, it is almost invariably the rule in the Bolton district to have only three passages of flyer frames, that is, slubbing, intermediate, and roving frames, making about a 12 hank roving, which, with double roving in mule, and 10 of a draft, will give 60's counts; and for 100's say four passages of flyer frames, viz., slubbing, intermediate, coarse roving, and fine roving, producing about 18 hank roving, which, with a draft of about 11 at the mule, will equal 100's.

60,120 mule spindles av. 60's at 21 hanks—about 21,042 lbs. per week of 55 hours from 12 hank.

Double Roving Sea Islands or Long Egyptian Cotton.

2 openers, 1 cylinder, 1 beater and lap; 2 single scutchers; 10 Horsfall's grinders.

65 single cards, 40in. x 50in., 110 S.S.F	@ 323	lbs.
5 drawing frames, 1 head of 8 dels.	,, 526	,,
10 lap doublers, 10½in. lap		
55 Heilman's combers, 8 boxes each, 10½in. laps	,, 382	,,
5 drawing frames, 2 heads of 8 } dels 16in staff	,, 526	,,
5 do. do. 1 do. of 8 } 1 undershaft		
5 x 88 slubbing, 10in., 19in. staff, 1·12 hank roving	,, $47\frac{8}{10}$	,,
13 x 126 intermediate, 9in. x 4¾in., 19¾in. staff, 3·5 hank roving	,, $12\frac{8}{10}$	,,
35 x 188 fine roving, 7in. x 3⅛in., 17¼in. staff, 12 hank roving	,, $3\frac{3}{10}$	,,
60 x 1002 S. A. mules, 1⅜in. distance, 63in. stretch, Bolton mules, single thread bosses.		

If with four passages of drawing and flyer frames.

60 single cards, 40in. x 50in., 110 S. S. F.	@ 350	lbs.
4 drawing frames, 1 x 8 dels.	,, 657	,,
10 lap machines	,, 1204	,,
55 Heilman's combers, 8 boxes each, $10\frac{1}{2}$in. laps	,, 382	,,
4 drawing, 2 x 8 4 do 1 x 8 } dels. 16in. staff 1 undershaft	,, 657	,,
4 x 72 slubbing, 10in. x $5\frac{1}{2}$in., 19in. staff, ·75 hank roving..	,, 73	,,
6 x 126 intermediate, 10in. x $4\frac{3}{4}$in., $19\frac{3}{4}$in. staff, 1·75 hank roving	,, $27\frac{8}{10}$	,,
12 x 140 coarse roving, 9in. x 4in., 24in. staff, 4·36 hank roving	,, $12\frac{5}{10}$	,,
36 x 188, fine roving, 7in. x $3\frac{1}{8}$in., $17\frac{1}{2}$in. staff, 12 hank roving	,, $3\frac{1}{10}$	,,

60 x 1002 S. A. mules, $1\frac{3}{8}$ distance, Bolton mules.

60,120 mule spindles, av. 100's, at 16 hanks—about 9,619 lbs. per week of 55 hours from 18 hank.

Double Roving Sea Islands Cotton.

1 opener, 1 cylinder, 1 beater and lap; 1 single scutcher.

40 single cards, 40in. x 50in., 110 S.S.F	240	lbs.
4 drawing frames, 1 x 5 dels.	,, 480	,,
4 lap doublers, $10\frac{1}{2}$in. laps	,, 2404	,,
26 Heilmann's combers, 8 boxes each, $10\frac{1}{2}$ in. laps	,, 369	,,
4 drawing frames, 2 x 5 dels.	,, 480	,,
2 x 88 slubbing, 10in. x. $5\frac{1}{2}$in., 19in. staff—1 hank roving...	,, $54\frac{6}{10}$	,,
4 x 108 intermediate, 10in. x $4\frac{3}{4}$in., $19\frac{3}{4}$in. do.—2·5 do....	,, $22\frac{2}{10}$	,,
10 x 140 roving, 8in. x 4in., 24in. do.—6·26 do.	,, $6\frac{8}{10}$	,,
26 x 188 fine rov., 6in. x $3\frac{1}{8}$in., $17\frac{1}{2}$in. do.— 18 do.	,, $1\frac{9}{10}$	,,

60 x 1002 S. A. mules, $1\frac{5}{16}$in., dist. 60 in. stretch, fine mules.

	Diam. of Rollers.	Speed of Rollers.	Dec. Hank.	Production in 54 hours.	Turns per in.
Drawing Frames ...	$1\frac{1}{2}\times1\frac{1}{2}\times1\frac{1}{2}\times1\frac{1}{2}$	290	·22	116 hanks.	
Slubbing do.	$1\frac{3}{8}\times1\frac{1}{8}\times1\frac{3}{8}$	450	·1	55 to 60	0·64
Intermediate do.	$1\frac{3}{8}\times1\frac{1}{8}\times1\frac{3}{8}$	610	2·5	55 to 60	1·03
Coarse roving.........	$1\frac{1}{4}\times1\frac{1}{8}\times1\frac{1}{4}$	750	6·26	46 to 48	1·6
Fine do.	$1\frac{1}{4}\times1\frac{1}{8}\times1\frac{1}{4}$	1030	18	34 to 36	3·0

PREPARING AND SPINNING MACHINERY FOR A 90,000 SPINDLE MILL; AVERAGE 75'S SOFT TWIST.

The tabulated productions as given are in yarn per week of 55 hours with the speed of rollers, spindles, and the turns of twist mentioned, after a due allowance has been made for stoppages, etc. We calculate the loss in stoppage for doffing, piecing, etc., roughly at say 25% in drawing frames, 20% in slubbing frames, 12% in intermediate frames, 7½% in roving frames, and 5% in fine roving frames. It will, however, be understood that the machines specified do not in all cases just agree with the productions mentioned, as allowances have to be made for contingencies, etc., and in order also to keep as much as possible the machinery divisible by some whole number, which has been kept in view.

90,000 MULE SPINDLES AND PREPARATION; AVERAGE 75'S SOFT TWIST AT 20 HANKS PER SPINDLE, CALCULATED TO PRODUCE ABOUT 24,000 LBS. OF YARN PER WEEK OF 55 HOURS, WORKING 15 DOUBLE-ROVING FROM SEA ISLANDS OR LONG EGYPTIAN COTTON.

3 openers, 1 cylinder, 1 beater and lap; 3 single scutchers; 8 patent card grinders; 2 common grinding rollers.

80 single cards, 40in. x 50in., 110 revolving iron flats	@	300	lbs.
5 drawing frames, 1 head of 8 deliveries	,,	600	,,
10 lap doublers, 10½in lap	,,	2400	,,
65 Heilman's combers, 10½in. laps, 8 boxes	,,	369	,,
15 drawing frames, 1 head of 5 and 1 head of 4 dels., 5 frames 3 x 9 dels.	,,	533	,,
5 x 80 slubbing frames 10in. x 5½in. bob, 19in. gauge, 9 hank roving	,,	60	,,

10 x 102 intermediate frames, 10in. x 4¾in. bob, 19¾in. gauge, 2·25 hank roving .... ,, 23$\frac{5}{16}$lbs.

20 x 140 roving frames, 8in. x 4in. bob, 24in. gauge, 5·6 hank roving.. ,, 8$\frac{5}{16}$,,

60 x 188 fine roving frames, 6in. 3⅛in. bob, 17½in. gauge, 15 hank roving .... ,, 2$\frac{1}{16}$,,

90 x 1000 S. A. mules, 1$\frac{5}{16}$in. dist. 63in. framing creels for double roving (Bolton Mules.)

Machine.	Diam. of Rollers.	Speed of Roller.	Dec. Hank.	Production in 55 hrs.	Turns per in.	Percentage of Loss.
Drawing Frame ..	1½ × 1¼ × 1½ × 1¼	290	0·20	116 hanks		25
Slubbing do. ...	1⅜ × 1⅛ × 1⅜	450 Speed of Sp.	0·9	55 to 60	0·64	20
Intermed. do. ...	1⅜ × 1⅛ × 1⅜	610	2·25	55 to 60	1·0	12
Coarse roving ...	1¼ × 1⅛ × 1¼	750	5·6	45 to 50	1·54	7½
Fine do. ...	1¼ × 1⅛ × 1¼	1080	15·	32 to 36	2·75	5

CROCHET THREAD is generally made with 24's to 28's yarns of good quality, Egyptian, combed, spun out of double roving and gassed.

KNITTING AND MENDING YARNS, &c.

A fair type of an ordinary mending or knitting yarn is 18's 3 threads, a large quantity being used (especially in coloured mixings), and sold for mendings either in small hanks or wound on paper cards.

The mixing for this and approximate numbers, is Tinnivelly mixed with about 10 per cent. of middling Orleans. The yarn is made into three threads on a winding frame, then doubled, the twist being the reverse way to the twist of the cop, the numbers of turns differing for each count. For 18's the twist put in is five or six turns per inch.

The yarn is then wound into hank (cross reeled) for the purpose of putting on the cards, or made into small hanks of a certain weight (half or quarter ounce), tied up separately into knots ready for the market.

A very large quantity of yarn made as above is sold as merino (*i.e.*, a mixture of wool and cotton), but it is really all cotton, the difference being that a portion is dyed, and then mixed with undyed, before putting through the lap machines.

KNITTING YARN is generally bleached, and, up to the counts mentioned, Tinnivelly cotton is the best to use, as it bleaches with more lustre than American.

There is no special difference between the yarn used for these cottons and ordinary yarns; for the coarse numbers a mixing of the above quality will do, for 30's and 40's good American, and 50's and 60's Egyptian. It is not necessary to comb, and whether spun from single or double roving is a matter for the judgment of the manager.

The following are the turns per inch for the three qualities, as worked by the best makers of these cottons:—

	10/3	20/3	30/3	40/3	50/3	60/3
Knittings 3-fold	8	11¼	13½	15	17	19
Darnings 3-fold	3	5	6	7½	9	10
Embroidery 3-fold ...	5½	8	9½	11	12½	14

A PREPARATION FOR SPINNING ABOUT 3,500 LBS. PER WEEK OF 56 HOURS OF 10's HOSIERY YARNS, EITHER COTTON OR MERINO, WHITE OR COLOURED.

1 Opener.
1 Finisher.
10 Carding Engines.
1 Derby Doubler.
1 Drawing Frame, 3 heads, 5 deliveries.
1 Slubbing Frame, 56 spindles.
1 Intermediate Frame, 112 spindles.
2 Jack Frames, 224 spindles each.
1 Pair of Mules, 1,800 spindles, $1\frac{5}{8}$ guage.

The great bulk of ordinary hosiery yarns used in Nottingham and Leicester is spun from Tinnivelly cotton mixed with about 10 per cent. of Middling Orleans into numbers from 4's to 15's, the average being about 10's. Other counts are also largely used, but as the numbers go finer, the mixing must also improve. The cotton requires very well cleaning and carding; it is, therefore, necessary to put it through an opener before making it into a lap, as moats and thick places are fatal to the manufacturing machines.

If coloured mixtures are required, the cotton is dyed in the raw state, and mixed with the white after it has been through the opener, and before putting into the scutcher or first lap machine.

FOR ALL COTTON.

1 Opener.
1 Finisher.
10 Carding Engines.
1 Drawing Frame, 3 heads, 5 deliveries.
1 Slubbing Frame, 56 spindles.
1 Intermediate Frame, 112 spindles.
2 Jack Frames, 224 spindles each.
1 pair Mules, 1⅝ guage, 1,800 spindles.

The above preparation is suitable for either coarse hosiery or yarns for towels, &c., but the creels in the mule should be left large enough for the intermediate bobbins in case very coarse numbers are required, such as 2's, 3's, or 4's, which are generally spun from the intermediate bobbin.

Knittings are made up in ½ lb. papers, and Mendings in ¼ lb. papers, and both in 5 lb. bundles.

SPINNING FINE NUMBERS.

In spinning fine numbers it is essential to be most careful and particular about the temperature and humidity of the room. If the room is too hot it is apt to get dry, which is worse than a cold temperature for spinning.

The Under Fallers should work very freely, and be perfectly sensitive to the touch of the yarn, and the bevel of the spindles will require increasing, and probably the "topping" lowering a little.

The number of turns put in whilst coming out, or the number of turns put in at the head whilst twisting, vary very much indeed from one mill to another, and more so than any variation in spinning coarse numbers.

One rule is to put in 75 turns for each turn of a one inch roller when coming out, and more or less according to the quality of the cotton, and to gain coming out, 6″ to 7″ and 3″ to 4″ the after-stretch. If the cotton is good the after-stretch is increased and the gain diminished and *vice versa.*

Another rule for doubling yarns is to put about half the coming out of the other when twisting at double speed, and in this case with a fair cotton would gain about 5″ and stretch about 4″ after the rollers stop. Some good spinners of these fine numbers will only put about 3″ gain coming out, and put about one-third of the turns in whilst coming out, and stretch after the rollers stop 8″ or 9″. The single speed should be about 3,000, and the double speed 7,000, or even more than this if preferred, but of course the backing off and going-up must be arranged to correspond, and with rope driving there is no difficulty.

The Under Fallers should work on Anti-friction Bowls, and the balancing should be carefully attended to.

A 30 to 35 hank-roving should be used for 200's.

The finest numbers usually spun with success on self-actors are 260's.

There is, however, really no reason why finer numbers should not be spun; the only questions being one of cost and the question of market.

You cannot afford to spin very fine numbers on such long mules as of course the production is great on account of the number of spindles, and the market for very fine yarns is strictly limited.

Another thing is this; that when people spin on self-actors they expect to make large cops, and in these fine yarns the cops will be on the spindle for days and days sometimes, and consequently the part that is on longest becomes dirtied with the dust in the room, thus depreciating the value of the yarn. Of course the small box-organ hand mules can spin in small cops, and the mules having a less number of spindles are easily manipulated and changed. This, as stated before, is entirely on account of the limited market, and where there is a good demand for 300's undoubtedly self-actors would crush the competition of the best hand mule yarn, but then it is worth no one's while to go into it.

When 150's or 160's are passed, it often becomes necessary to double comb the cotton in order to have as clean and even a roving as possible for working in the mule. With the double combing begins the principal trouble, inasmuch as the fibres in the sliver, being parallel, have lost to a great extent their hold on each other, and the slightest shock or strain is liable to break the sliver; furthermore, although the sliver might not be broken, it is often stretched, making an irregular yarn.

Spinning, say 300's to 350's, on self-actor mules, the following process has to be gone through:—

In the first place the cotton must be of good class of really Sea Island, not Florida or Fiji. It should be pulled open by hand first, and then opened by one porcupine cylinder running about the usual speed for Sea Island, and then passed by one single scutcher with the two-bladed beater running at about 900 revolutions. On this finishing machine a lap will be made weighing 10oz. per yard; care must be taken that the inside of the machine is thoroughly cleaned and free from rough places, and the feed rollers must be set well clear of the teeth of the porcupine, or the blade of the beater.

Then in the carding, the card cylinder, if a 50-in. diameter, should run from 130 to 135 revolutions per minute, not more; and the card must not be expected to produce more than from 70 to 80 lbs. per week. The stripping and grinding must be carefully attended to, and it is important to see that no more short fibre and dirt go forward than can be helped. The weight of the sliver coming off the card will be 15 grains per yard, and the card should make 7½ per cent. of waste. The draft of the card must be considerably more than the usual numbers, 150's to 200's, and the flats should be 2″ wide. There should be two feed rollers instead of the dish feed. and no licker-in. This sliver is made into a lap in the ordinary way, and placed behind the first comber; naturally this comber will require regulating and setting for the length of the Sea Island staple, and ought not to run more than 60 nips per minute. The first comber should take out 15 per cent. waste, making a sliver of 20 grains per yard. This sliver is made into a lap again, and placed behind the second comber, which, with the same setting and speed, should produce 7 per cent. of waste, and make a sliver of about 20 grains per yard.

There are three passages of draw frame with 8 ends up $7\frac{3}{4}$ draft, making a sliver 24 grains per yard. For the class of cotton spoken of, the front and second top rollers should be set $1\frac{7}{8}$-in. apart, and the top rollers should not be less than $1\frac{1}{4}$-in. diameter.

Cans with spring bottoms will be required to assist the sliver to mount, and the very greatest care must be taken that the passage of the sliver is not obstructed by anything rough or moist. With this double-combed cotton everything is so delicate that it has been found that the mere passing of the hand over a polished plate is sufficient to prevent the cotton passing. All polished work should be repolished with flour emery, or rouge, and maintained constantly in a state of perfect polish.

Coming from the draw frame, the sliver, again in spring bottom cans, is placed behind the slubbing frame which must be provided with a large japanned or brass roller, to help to lift the sliver out of the can in the passage of the rollers. The rollers are set $1\frac{13}{16}$ in. from front to middle. They have large top rollers, the front being $1\frac{5}{8}$ in. diameter; the sliver made will be a 2-hank, front roller $1\frac{1}{4}$ in. diameter, spindle makes $3\frac{1}{4}$ turns for one of front roller.

Before using these fliers they must be thoroughly well cleaned inside, and polished as perfectly as is practicable by drawing soft untwisted bands with flour emery and subsequently rouge. The cotton becomes highly electrical, and will stick in the most astonishing manner to any surface that gives the slightest excuse for doing so.

The intermediate is two ends into one, and makes a 5½-hank, front roller 1¼ in. diameter, spindle makes 4¼ turns for one of roller.

The rover is with soft bobbin fliers, doubles two into one, and makes a 15-hank, front roller being 1¼ in. diameter, and the spindle making seven turns for one of the roller.

The jack frame, also soft bobbin with say 6 in. lift, but 5 in. is better, doubling two into one, will make a 40-hank roving, the front roller 1¼ in. diameter, the spindle makes fifteen turns for one of the roller.

In all the fly frames the greatest possible attention must be paid to the finish and smoothness of the rollers, fliers, and traverses, and on the jack frame the bobbins must be as light as is consistent with the strength required.

The skewers on all the frames and in the mule creels must be most minutely examined to ascertain that there is no unnecessary friction on the pivot, and any bad pot steps should be at once changed, as also any defective skewers. The roving rods and the traverse guides, both back and middle, will require also special attention, on account of the tendency of this double combed cotton to twist and catch round anything in its way.

Coming to the mule, as the cops made are so very small, the spindle is made to correspond. The mule may have any number of spindles up to 960 or even 1,000 according to requirements of the trade; we should prefer to have it about 860. The mule consists of say 860 spindles 1¼″ space, 14″ spindle, 6″ out, 5½ bevel, 54″ stretch, 3 lines of rollers single boss self weighted, not case hardened; all faller rods working on anti-friction bowls, the under faller being of small diameter and very carefully balanced. The mule should have double speeds, after stretch, roller motion, and motion whilst twisting, faller motion and patent governor motion, in addition to which some of the motions generally performed by the carriage in its traverse would have to be done by automatic motions positively driven, this in order to ease the resistance in the carriage and leave it perfectly free.

Of course, when spinning these numbers, it is of much less importance to produce much than to produce it well, so all the speeds, both of spindles, backing-off and running-up, are reduced much below the average; thus, instead of backing-off and running-up in four seconds, it is as well to take five or five-and-half, and no mule will spin these fine numbers unless the lighting up be perfect, *i.e.*, when striking the stops there should be no tendency to rebound, anything of this sort will produce snarls.

To speak generally on the subject of these fine numbers, it may be truly said that the principal difficulty is one of small details in the matter of cleanliness and smoothness, as pointed out; no doubt, according to climatic conditions, the setting of the rollers may require modification. What is given here is what is practicable, and has been practicably attained successfully in the damp climate of Lancashire, and it is to be presumed that if the hygrometric conditions are the same in any other country, the practical results should be the same. This is, of course, a matter of experience. There are mules in France which are regularly spinning 250's English, and most successfully. Of course, with the addition of humidity, the electrical condition is modified, and there is one state of damp air both as regards heat and humidity, but much of this electrical difficulty is reduced to a minimum. The heat should not be less than 90 degrees; it is also necessary to take special precautions to prevent dirty air getting into the room, as the cops, being so long on the spindle, become very filthy on the bottom, unless this precaution is taken.

It would be well to state that a very slight variation in the irregularity of the roving from yard to yard will make, in these fine numbers, an enormous difference in the numbers of the yarn. Thus in 300's a difference of 30 hanks is nothing at all unusual, and even an extreme difference of 50 is not remarkable.

The difference between a successful and non-successful spinner of these numbers consists in avoiding these large variations.

This can only be done by great care in details. See that the roller pivots are all free; that the rollers are equally covered as regards diameter; that the weight of the slivers and roving is frequently checked, and any variation compensated. Furthermore, it is advisable to have the wood bobbins of an absolutely exact weight, and then the full bobbins should be weighed and classified, so that there shall not be a greater extreme variation than, say, 5 per cent.

It is scarcely necessary to say that the main element of success in this, as in all other spinning of good qualities, lies principally in absolute cleanliness.

It is advisable to run fine tissue paper through the Derby Doubler and Ribbon Lapper Laps the second time the cotton is passed through these machines. This simple device will be found very effective in preventing "licking." It is also well to put paper tubes on the Jack Bobbins, by which means considerably less twist may be put in this very fine hank roving.

MISCELLANEOUS NOTES.

Shafting.

The shafting put in cotton mills to-day is somewhat similar to the shafting used 20 years ago with a little qualification.

The off-end length of a shaft is always the weakest, and the end bay of a mill is always the widest, and as mules are now longer than they were 20 years ago and require more power, this end of the shaft should be not less than $2\frac{3}{4}$ in. diameter, whether of steel or wrought iron, on account of sag or deflection; it used to be $2\frac{1}{2}$ in. or $2\frac{5}{8}$ in. diameter.

The ordinary bays of mills in Europe are now 10 feet 6 inches, and for India 11 feet, so that no diminution of shaft can be allowed, though the speeds are quicker and the shafts, therefore, convey more power.

It is only when shafts at the gearing end of the mill are not less than 4 in. diameter in wrought iron, that a reduction can be made if a shaft of similar power is to be put in of steel on account of deflection by the weight of driving pulleys.

EXAMPLES.

Card Room	Shafts	10 bays	=108 feet.	3″ thick end	down to	2¾″	thin end.
,,	,,	20 ,,	=213 ,,	3¾″ ,,	,,	2¾″	,,
Mule	,,	10 ,,	=108 ,,	3¼″ ,,	,,	2¾″	,,
,,	,,	20 ,,	=213 ,,	4″ ,,	,,	2¾″	,,
Throstle	,,	10 ,,	=108 ,,	4″ ,,	,,	3″	,,
,,	,,	20 ,,	=213 ,,	5″ ,,	,,	3″	,,

HORSE POWER.

Openers and Scutchers—per beater of cylinder		5	I.H.P.
Cards with modern production ...	each	1	,,
Drawing frame per 12 deliveries ...	,,	1	,,
Comber 8 heads	,,	¾	,,
Slubbing Frame, 70 to 90 spindles ...	,,	2	,,
Intermediate Frames, 120 to 136 spindles	,,	2	,,
Roving Frame, 160 to 180 spindles...	,,	2	,,
Jack Frames, 200 to 220 spindles ...	,,	2	,,
Mule Nos. up to 50's 120 spindles ...	,,	1	,,
Mule Nos. 50's to 100's, 120 to 140 spindles	,,	1	,,
Ring Frames, 76 spindles	,,	1	,,

PRODUCTION OF SLUBBING FRAME.
INDIAN COTTON.

Diameter of front roller, 1¼ inches. Working hours of Mill, 56½. Actual working hours of frame, 44.

Revolutions of spindles.	Turns of spindle for 1 of F. R.	Revolutions of front rollers.	Hank roving.	Hanks per Spindle.	lbs. per Spindle.
550	3¾	146	½	49·77	99·54
	4	137·5	⅝	46·6	74·5
	4⅛	133	¾	45·23	60
	4¼	129·4	⅞	43·8	50
	4⅜	118	1	42·6	42·6

PRODUCTION OF INTERMEDIATE FRAME.
INDIAN COTTON.

Diameter of front roller, 1¼ inches. Working hours of mill, 56½. Actual working hours of frame, 47.

Revolutions of Spindles.	Turns of Spindle for 1 of F. R.	Revolutions of front roller.	Hank Roving.	Hanks per Spindle.	lbs. per Spindle.
700	4¾	147·3	1	54	54
	5½	127·4	1¼	46·5	37·2
	6¼	112	1½	41	27·33
	7	100	1¾	37·8	21·3
	7½	93·3	2	34·2	17·11
	8	87·5	2½	32	12·8
	8¼	84·8	3	31	10·33

PRODUCTION OF ROVING FRAME.

INDIAN COTTON.

Diameter of front roller, 1⅛ inches. Working hours of mill, 56½. Actual working hours of frame, 50.

Revolutions of Spindles.	Turns of Spindle for 1 of F. R.	Revolutions of Front Roller.	Hank Roving.	Hanks per Spindle.	lbs. per Spindle.
1050	7·25	144	1¾	50	27·4
	7·5	140	2	49	23·5
	7·75	135·4	2¼	47	20
	8·125	129	2½	45	17·34
	8·5	123·5	2¾	42·8	15
	9·	116·6	3	40·8	13
	9·5	110·5	3½	38·3	10·57
	9·8	107	3¾	37	9·59
	10·2	102·9	4	35·75	8·65

PRODUCTION OF SLUBBING FRAME.

AMERICAN COTTON.

Diameter of front roller 1¼ inches. Working hours of mill 56½. Actual working hours of frame 44.

Revolutions of Spindles.	Turns of Spindle for 1 of F. R.	Revolutions of Front Roller.	Hank Roving.	Hanks per Spindle.	lbs. per Spindle.
470	3	156	⅜	53	141
	3	156	½	53	106
	3⅛	150	⅝	51	81·6
	3¼	144	¾	49	65·3
	3½	134	⅞	45·8	52·3
	3¾	125	1	42·7	42·7
	4	117	1⅛	40	35·5
	4¼	110	1¼	37·6	30

PRODUCTION OF INTERMEDIATE FRAME.

AMERICAN COTTON.

Diameter of front roller, 1¼ inches. Working hours of mill, 56½. Actual working hours of frame, 48.

Revolutions of Spindles.	Turns of Spindles for 1 of F. R.	Revolutions of Front Roller.	Hank Roving.	Hanks per Spindle.	lbs. per Spindle.
700	4¾	147	1	54.8	54.8
	5	140	1¼	52	41.6
	5⅜	130	1½	48.5	32.3
	5⅞	119	1¾	44.4	25·37
	6¼	112	2	41.8	20.9
	6¾	103	2½	38.4	15.36
	7	100	3	37	12.33

PRODUCTION OF ROVING FRAME.

AMERICAN COTTON.

Diameter of front roller, 1⅛ inches. Working hours of mill, 56½, Actual working hours of frame, 51.

Revolutions of Spindles.	Turns of Spindles for 1 of F. R.	Revolutions of Front Roller.	Hank Roving.	Hanks per Spindle	lbs. per Spindle.
1050	7	150	2	53·6	26·9
	7¼	144	2¼	51·4	22·4
	7⅜	142	2½	50·7	20·28
	7½	140	2¾	50	18·18
	7¾	136	3	48·5	16·16
	8¼	127	3½	45·3	12·9
	8⅝	121	3¾	43	11·46
	8⅞	118	4	42	10·5
	9⅛	115	4¼	41	9·6
	9½	110	4½	39·29	8·7
	9¾	107	5	38·22	7·64
	10	105	5½	37·5	6·8
	10½	100	6	35·7	5·95
	10¾	97	6½	34·6	5·3
	11	95	7	33·9	4·8

PRODUCTION OF SLUBBING FRAME.
EGYPTIAN COTTON.

Diameter of front roller 1⅜ inches. Working hours of mill 56½. Actual working hours of frame 44.

Revolutions of Spindles.	Turns of Spindle for 1 of F. R.	Revolutions of Front Roller.	Hank Roving.	Hanks per Spindle.	lbs. per Spindle.
400	2·5	160	½	60	120
	2·65	150	⅝	56	89·6
	2·75	145	¾	54	72
	2·85	140	⅞	52	59·4
	3·	133	1	49·9	49·9
	3·25	123	1⅛	46	40·8
	3·5	114	1¼	42·7	34·16
	3·65	109	1½	40·9	27·26

PRODUCTION OF INTERMEDIATE FRAME.
EGYPTIAN COTTON.

Diameter of front roller 1¼ inches. Working hours of mill 56½. Actual working hours of frame 48.

Revolutions of Spindles.	Turns of Spindle for 1 of F.R.	Revolutions of Front Roller.	Hank Roving.	Hanks per Spindle.	lbs. per Spindle.
650	5·18	125	2½	46·6	18·64
	5·25	123·8	3	46	15·33
	5·5	118	3½	44	12·57
	5·75	113	3¾	42	11·2
	6	108	4	40·3	10·075
	6·25	104	4¼	38·8	9·17
	6·5	100	4½	37·3	8·28

PRODUCTION OF JACK FRAME.
EGYPTIAN COTTON.

Diameter of front roller, 1¼ inches. Working hours of mill, 56½. Actual working hours of frame, 52.

Revolutions of Spindles.	Turns of Spindles for 1 of F. R.	Revolutions of Front Roller.	Hank Roving.	Hanks per Spindle.	lbs. per Spindle.
1050	9	116.6	8	47	5.875
	9½	110.5	9	44.6	4.95
	10	105	9½	42.4	4.46
	10½	100	10	40.4	4.04
	10¾	97.6	10½	39.3	3.74
	11	95	11	38.4	3.49
	11½	92	11½	37	3.21
	12	87.6	12	35.4	2.95
	12½	84	13	33.9	2.6
	13½	77.7	14	31.4	2.24
	14	75	15	30.2	2
	14½	72	16	29	1.8

THE FOLLOWING IS THE MACHINERY REQUIRED FOR A MILL IN INDIA OF 19,936 RING THROSTLE SPINDLES.

2	Double Crighton Openers.				
9	Single Scutchers.				
52	Cards, 50 in. x 37 in.				
9	Draw Frames, each 3 heads, 6 deliveries.				
9	Slubbing Frames,	60	spindles each,	10″ space,	10″ lift.
12	Intermediate „	116	„ „	6½″ „	10″ „
26	Roving „	152	„ „	5″ „	7″ „
56	Ring Throstles	356	„ „	2⅝″ „	5″ „

84 Ordinary Reels.
4 Bundling Presses.

THE FOLLOWING IS THE MACHINERY REQUIRED FOR A MILL IN INDIA OF 20,064 MULE SPINDLES.

2 Double Crighton Openers.
9 Single Scutchers.
40 Cards, 50″ x 37″.
7 Draw Frames, each 3 heads, 6 deliveries.
7 Slubbing Frames, 60 spindles each, 10″ space, 10″ lift.
9 Intermediate ,, 116 ,, ,, 6½″ ,, 10″ ,,
20 Roving ,, 152 ,, ,, 5″ ,, 7″ ,,
24 Mules 836 ,, ,, 1⅜″ ,,
72 Ordinary Reels.
4 Bundling Presses.

PROPORTION OF SPINDLES.

S. A. MULE SPINNING 80's WEFT.

1189 Mule Spindles to 1 Card 50″ × 37″.
1685 ,, ,, ,, 1 Draw frame finishing delivery.
126·4 ,, ,, ,, 1 Slubbing frame spindle.
37·7 ,, ,, ,, 1 Intermediate frame spindle.
8·18 ,, ,, ,, 1 Jack frame spindle.

S. A. Mule Spinning 80's Twist Combed.

1212 Mule Spindles to 1 Card.
10000 ,, ,, ,, 1 Lap machine.
10000 ,, ,, ,, 1 Combined lap machine.
1428 ,, ,, ,, 1 Combing machine.
1666 ,, ,, ,, 1 Draw frame finishing delivery.
128·2 ,, ,, ,, 1 Slubbing frame spindle.
43 ,, ,, ,, 1 Intermediate frame spindle.
9·6 ,, ,, ,, 1 Jack frame spindle.

S. A. Mule Spinning 60's Twist.

888 Mule Spindles to 1 Card 50″ × 37″
1392 ,, ,, ,, 1 Draw frame finishing delivery.
108·7 ,, ,, ,, 1 Slubbing frame spindle.
38·9 ,, ,, ,, 1 Intermediate frame spindle.
8·4 ,, ,, ,, 1 Jack frame spindle.

S. A. Mule Spinning 70's Weft.

1071 Mule Spindles to 1 Card 50″ × 37″
1453 ,, ,, ,, 1 Draw frame finishing delivery.
106 ,, ,, ,, 1 Slubbing frame spindle.
37·9 ,, ,, ,, 1 Intermediate frame spindle.
8·23 ,, ,, ,, 1 Jack frame spindle.

S. A. Mule Spinning 70's Twist.

1040 Mule Spindles to 1 Card 50″ × 37″
1485 ,, ,, ,, 1 Draw frame finishing delivery.
108·3 ,, ,, ,, 1 Slubbing frame spindle.
38·8 ,, ,, ,, 1 Intermediate frame spindle.
8·4 ,, ,, ,, 1 Jack frame spindle

Ring Throstle Spinning 24's Twist.

364·8 Ring Spindles to 1 Card 50′×38′.
430 „ „ „ 1 Draw frame finishing delivery.
37·6 „ „ „ 1 Slubbing frame spindle.
18·8 „ „ „ 1 Intermediate frame spindle.
5·9 „ „ „ 1 Roving „ „

S. A. Mule Spinning 32's Twist.

759 Mule Spindles to 1 Card 50′×38′.
867 „ „ „ 1 Draw frame finishing delivery.
79·8 „ „ „ 1 Slubbing frame spindle.
29·3 „ „ „ 1 Intermediate frame spindle.
9.9 „ „ „ 1 Roving „ „

S. A. Mule Spinning 40's Weft.

1031·6 Mule Spindles to 1 Card 50′×38′.
1238 „ „ „ 1 Draw frame finishing delivery.
97·7 „ „ „ 1 Slubbing frame spindle.
42·7 „ „ „ 1 Intermediate frame spindle.
12·8 „ „ „ 1 Roving „ „

Gassing Frames.

At the rate of 3000 inches per minute, 290 hanks per light will be produced in an English week, divide, therefore 290 by the counts when doubled (100−2 cord=50's) and you have the weight produced per light per week, and at 4000 inches per minute the production would be one-third more. Yarn which is 50's before gassing is 55's after gassing.

For 40's 2-cord say the ends to go through the light at the rate of 3000 inches per minute, and run say 54 hours out of 56½, or a gassing frame will run the same hours as a mule out of 56½.

A tenter will mind as under:—

If from	warpers	bobbins	4½″	72 lights.
,,	clearer	,,	3″	50 ,,
,,	doubler	,,	2½″	30 ,,

A tenter minding 50 lights, the thread running 3000 inches per minute, would produce some 700 lbs. of 2 cord 50's per week. The quality of gassing is known only to the buyer and seller. If working from warpers bobbins the lights and the speed of the yarn should be reduced one-half to avoid breakage of the thread.

THE ROLLER COVERING DEPARTMENT.

It is impossible to exaggerate the importance of this department. The most careful attention and particularity should be bestowed upon covering the top rollers with cloth and leather.

This work should be executed with great nicety and exactness, so as to ensure a smooth, level, and even yarn.

Especial care should be given to the "piecings," which should be made so exact and perfect as not to be detected when the rollers are covered and ready for use.

All mills now-a-days are supplied with a complete set of roller covering machinery, which consists of the following, viz:—A machine for grinding the skins down to an even thickness, all skins being more or less uneven, no matter how carefully prepared or sorted.

This machine is very valuable, and reduces the element of uneven rollers to a minimum.

Second.—A splicing machine. In this machine the strips of roller leather are cut to the required length for each roller; the cut edges are bevelled, and thus when glued together they overlap each other and become equal in thickness to the rest of the leather forming a cot or cylinder of uniform "heft," which is a very important feature, doing away with thick and thin places.

These covers are drawn on to the rollers by a drawing-on apparatus familiar to anyone engaged in the mill.

Third.—An ending machine, which secures the ends of the covers, and turning them down gives a secure grip on each end of the boss of each roller.

Fourth.—A rolling machine which subjects the covered rollers to a rolling pressure, rendering them as uniformly round, solid and even as possible.

Fifth.—A trueing-up machine, which may be compared to a lathe. In this machine the rollers are ground or turned up by being subjected to the action of a revolving disc covered with fine glass paper.

It is especially advisable to true up the top leather detaching-rollers of combers in this way.

The leather itself which is specially prepared from sheep and goat skins should be of the very best quality, any false or cheap economy on this head is sure to lead to most unfavourable and wasteful results, and should therefore be strictly avoided. Poor quality or so-called cheap skins are very dear skins in the long run. The skins before being cut up should, on account of the variation in thickness and evenness, be carefully sorted and picked, so as to get them in lots as even running as possible. The skins should be of a soft and pliable nature, so that in being drawn on to the rollers they will not crack, but give nicely, like a good French kid glove when being drawn on the hand, and present a smooth and even surface; this will tend greatly to produce a smooth and wiry yarn.

The rollers should likewise be covered as tightly as possible, and the object of covering the top rollers with cloth and leather is to give a soft, yet firm grip to the roving and yarn.

Again we repeat – this all-important work should be under the strictest surveillance.

Any extra care and attention devoted to this department will be fully repaid upon examination of the yarn.

WASTE.

The waste that is made in a cotton mill is a very serious item, and upon a little reflection it will be seen that unless very great care and attention are bestowed upon this matter, in each and every department of the mill, any carelessness or neglect on the part of the workpeople will result in heavy loss. It is therefore necessary to be both very particular and strict upon this most important point.

At the scutchers nothing should be allowed to be beaten out of the cotton, or lost, except what is absolutely necessary; such as sand, seeds, and heavy dirt; any real cotton of any staple that may be getting knocked out with the fly, &c., should at once be stopped, and the evil remedied by closing up the bars at the back of the beaters.

To prevent any extra fly being made at the carding engine, if the cotton is anything like clean, and the yarn is giving satisfaction, the cards should not be allowed to run without grids or under-covers under the cylinders, more especially if there is plenty of carding in proportion to the number of spinning spindles, and if the cards are not overloaded. The strips, of course, must be regulated to the quality of cotton used and yarn required; but much waste in the form of strips may be avoided by a little extra care and attention to surrounding circumstances.

The cards will carry and make much less strips if they are kept sharp and well set. The lap piecers or carriers, and can and drawing frame tenters, may prevent much soft waste by seeing that the cans do not get choked up or run over; and drawing frame roller laps may be avoided by keeping the leather rollers clean, nicely varnished, and in good working order. The rovings at the frames, throstles, and mules should be made to run off to the very end; many tenters and piecers have a bad habit of roving off and pulling to waste the last row or so of rove which remains on the bobbins or tubes, and which would otherwise draw off, and be spun into yarn. This should not be allowed.

In one word, as little waste as possible should be made at every machine all through the process, and should not be permitted except within reasonable limits.

The waste that is made, and that cannot be avoided, should not be carelessly thrown on the floors, nor should it be dirtied. The different kinds of waste should be kept separate, and the fly, strips, roller and clearer waste and sweepings should be carefully picked.

The soft waste may be used up with advantage, and put into the weft mixing in a fair proportion. For the fly and strips a mixing may be made for say 24's twist as follows:—One-third ordinary cotton, one-third soft waste, and one-third fly and strips.

The low fly and strips, first sweepings, and clearer dirt, &c., may be worked up in low numbers, or sold.

GENERAL STORES.

The stores, such as card clothing, strapping, roller skins, tubes, banding, &c., &c., should be of a good quality. It is much better in the long run to expend a little extra money upon these necessary articles, than tc lay in, or work with a stock of second rate material. The first out-lay is rather more, but the extra expense incurred is fully recouped, as the articles, if of a fair quality, will last much longer, and do their work better than cheap and poor stuff.

The card clothing especially should be of a first-class quality, and should be got from the best makers. If it is not up to the mark the teeth or wires soon begin to break out, and then the cards require re-covering, as when the card clothing gets damaged it is impossible for it to do its work efficiently. Card clothing is a very expensive article, and becomes much more so if of an inferior make or quality.

The strapping should also be of a good quality, it will then run a reasonable time, and there will be less stopping of the various machines, through the strapping breaking, which is invariably the case when it is of a poor nature. The continued stopping of the machinery is a very serious matter, and can be avoided to a great extent by the use of good strapping, which will thus pay for itself, independently of any other consideration.

The above remarks apply to all the stores of whatever description, and may be summed up in one word, *i.e.*, reasonable and fair results if the articles be of a good quality; unsatisfactory and poor results if of an inferior quality. The manager should himself decide as to whether or not the various articles are of a sufficiently good quality, and give satisfaction in working. He should not take the mere word of anyone in the place upon this point, but should personally satisfy himself, as for obvious and well-known reasons, such word, in many instances, is not to be relied upon.

The looking after and giving out of the stores should be in the hands of a trustworthy and reliable man, upon whom nevertheless there should be an effective check. The store-room should be open an hour a day, say from 10 to 11 a.m., and each overlooker should then present himself to the store-keeper, with his book, in which are duly written the articles he may require, and signed by the manager. A certain amount of oil each day should be carefully measured out to each department. Cards, strapping, bobbins, &c., should be made to last a reasonable and proper time; any carelessness or negligence on this head should be strictly avoided. Altogether this department should be carried on with a system second to none in the mill.

VARNISH FOR LEATHER ROLLERS.

6 ozs. Navy Blue,
1 oz. Ordinary Glue.
$\frac{1}{4}$ oz. Fish Glue.
$\frac{1}{4}$ oz. Gum Arabic.

With $2\frac{1}{2}$ gills of water, to simmer for one hour.

CEMENT FOR LEATHER ROLLERS.

Fish glue, or isinglass, torn into small shreds, and as much vinegar as will dissolve the isinglass. To stand all night, and then let down with vinegar to proper thickness.

CEMENT FOR CLOTH.

2 lbs. White Flour.
1 lb. Unmade Resin.
$\frac{1}{2}$ lb. Turpentine.

To boil in one quart of water. Also for Cloth:—A thin coating of boiled-oil and white lead.

The cutting up of the skins should be closely watched, so as to prevent waste.

OILING THE MACHINERY.

The oiling of the machinery, well and regularly, is of the very greatest importance, for a machine which is regularly oiled will last a great deal longer, do its work better, and require less repairing than one which is neglected in this respect. Everything which moves ought to be oiled, for where there is moving there is friction, and where there is friction there is wearing, and to prevent this wearing oil is required. There can be no doubt that in the long run it is far better and more economical to use good oil; the evil consequences attending the use of poor or bad oil are great and serious.

System of Oiling for Frame Room.

Oil all shafts, differential motion, drums, loose pulleys, and all gearing every morning.

Spindle steps once every four weeks.

Spindle and bobbin shafts every Saturday.

Spindle and bobbin shaft bearings to be refilled with tallow once a month.

Slides, lifting shaft, and outside lift wheels on Monday morning.

Changing motions, such as taper, rack and slide, etc., on Monday morning.

All other racks to be filled with soft tallow and oiled on Saturday morning, tallow to be renewed every eight weeks.

Bobbin pulleys to be oiled every doff, except coarse frames, which are oiled twice a day.

Steaming in Cotton Mills.

The atmosphere is capable of holding in suspension a considerable amount of moisture. This is a fact, the knowledge of which may be of considerable advantage to a millowner, for moisture is well known to be a great assistant in spinning and weaving. It is undoubtedly advisable to introduce steam into mills, not only for the benefit of the cotton, but also for the "hands," for it increases the amount of moisture contained in the air. A continuous north or north-east wind dries the air in the mill, and is as injurious to the hands as it is disadvantageous to the cotton; to enable the air to hold a certain amount of moisture it must be raised to a proper temperature. Warm air holds more moisture than cold air, but of course there is a limit. What, therefore, it is necessary to point out, is the fact that the introduction of steam must be accompanied by the introduction of heat, for where the latter is deficient the steam will condense, and then there will be water instead of steam, which again will absorb heat from all surrounding objects, and thus produce the chilly feeling so injurious to health.

SPEEDS OF LINE SHAFTS.

The great velocity now given to the rim shafts of mules has caused the line shafts of spinning mills to be driven very much more quickly; formerly 180 to 200 revolutions per minute was considered a good speed, but with quicker rim shafts a speed of 240 to 250 revolutions is now desirable, so as to avoid the use of large drums and small pulleys on the counter-shafts.

The difficulty of obtaining these high velocities by direct driving has led to the introduction of belt and rope driving in almost all cotton mills recently built; rope driving especially having become very general, and with most satisfactory results; a steadier motion being imparted to the machinery, with less frequent breakdowns. The adoption of belt and rope driving has been greatly influenced by the number of breakdowns where gearing was used.

Where rope or strap driving has not been introduced—these instances, however, are very few—cast-steel wheels have been generally substituted for the broken cast-iron ones.

Depreciation of Machinery.

For depreciation of the machinery in a cotton mill there should be a proper percentage written off annually, and the percentage of depreciation ought to enter into the annual calculation, for little as it may in a profitable year affect the balance of this one year by itself, it is of very serious importance when the result of several years' trading is taken into account. For the depreciation of machinery and other property the correct amount should be set aside each year. The wear and tear in the working of a mill is constant and great, and becomes a very serious item; it is therefore necessary to make the proper allowance for it. To work on year after year without giving this matter any serious thought, or to deceive oneself wilfully or through ignorance, is a very gross miscalculation, and in time is sure to be attended with disastrous consequences.

In a well-conducted establishment the amount depreciated represents the amount of capital withdrawn, and the sum should be taken and put aside before anything is placed to the profit account or distributed in dividends. If it is distributed thus or consumed in any other way it constitutes a draft upon the capital, and in such a case it will be easy to calculate how soon the fund will become exhausted. The depreciation fund ought to be kept intact for the purpose of renewing the plant or of withdrawing the capital, as may be deemed most desirable. But even when the depreciation fund is frittered away it is desirable to go on depreciating, because after it is done the present amount of the capital is correctly shown, by which it is known how much interest requires to be allocated to capital, and what strictly speaking is the cost of production of the yarn or cloth at the time, and the owner thereby learns what he may properly charge, or rather accept, without actual loss, for his goods. To depreciate a mill when no depreciation has taken place would be wrong, but then depreciation is always taking place, and values are never permanent. A working mill depreciates through the wear and tear of the machinery; an idle mill through rust, neglect, and natural decay; both are liable to depreciate by the progress of invention, resulting in improvements that render the machinery valueless. Thus "the value of a mill" never "remains," neither when working or idle, and the care of the owner ought to be to get his capital back from it intact before it is irretrievably lost.

JOTTINGS AND USEFUL HINTS.

To gain power you lose speed. To gain speed you lose power.

In a mill, it is of great advantage to have plenty of driving power, so that a regular and uniform speed may be kept up; plenty of preparation machinery, and plenty of room, so as to allow the machinery to be laid out to advantage.

Every machine in the mill should be adjusted with the greatest precision, and kept in perfect working order.

The scutchers should be pulled to pieces, and cleaned thoroughly whenever there is a chance, and the flues should be swept and emptied regularly.

The speeds and spinning machinery should be thoroughly and regularly scoured.

Scutch and card light, and make as fine a roving as possible.

If the laps are kept regular, and of one weight, little or no alteration is required in the after process; but when necessary to change it is better to do so at the drawing.

The number of wires contained in 4 inches long (of wire) equals counts of wire.

To make the laps heavier, make the weighings heavier; or where self-regulating, speed the feed rollers.

To prepare light in the card-room is the best method for making a superior quality of rove or yarn.

Yarn spun from coarse rovings is never so beautifully even and wiry as yarn spun from fine roving.

On account of the distance between the third and back rollers in the drawing frame, or the middle and back rollers in the speeds or mules, when set so far apart, anything but a very little draught would be injurious.

To produce a regular yarn on the common fly throstle it is necessary to have good washers for the drag.

Potash and hot water is a capital thing for cleaning machinery.

The end of all government is order.

Always be on the alert to prevent faults rather than to check them after they have occurred.

Piece-work and " bounty " stimulates the work-people to greater exertion.

Consumption and production is according to traversing of rollers, which in all cases will be found by multiplying number of revolutions of rollers by circumferences.

The total draft of any machine where there are intermediate drafts may be found by multiplying the drafts respectively into each other, the sum of which will be total draft.

The scutcher is the best place for the thorough good mixing of cotton, when two or three kinds have to be incorporated, in the proportions of one in four, one in three; two in four, two in three; or three in four.

To prevent soft cops, see that the fallers are properly weighted, and see also that the spindle bands are tight.

Waste made at the carding engine, with and without grid or under-cover :—

Example.

Without Grid.	lbs.	oz.	
1 Lap 34½lbs. Egyptian...	1	0	1st fly
„ „ ...	0	11	2nd do.
„ „ ...	0	4	1st strips
Total......	1	15	

With Grid.	lbs.	oz.	
1 Lap 34½lbs. Egyptian...	0	6	3rd fly
„ „ ...	0	3	sand
„ „ ...	0	3	strips
Total......	0	12	

Patent plate iron bobbin caps for slubbing, intermediate, or roving tubes:—These caps are admitted to be the best and most effective caps yet introduced. They combine lightness with great strength, cannot possibly get loose in working; run steadier than the cast-iron hoops, secure perfect protection against breakages, and are fast superseding the cast-iron hoops.

If the feed rollers in the scutcher are "licking," set the back bar close up to the bottom roller to prevent this nuisance. If "plucking," *i.e.*, coming in in lumps —thick and thin—weight heavier, and see that the roller necks and steps are not worn.

If the scutcher-beater blades become worn round, turn the beater, so as to bring the sharp side of the blade into action on the cotton. If both sides of the blade are worn, the blades require planing up.

If the frames or speeds are all one gear, and of one date, and also working the same hank roving, be careful to have the drum-end wheels, rack, lifter, twist wheels, pinions, and wheel on bottom of upright alike in all frames.

RECIPE IN CASE SHAFT RUNS HOT.

Black antimony and best castor oil; you may if you like add a little black lead. Work it up nicely together, and lay it on the shaft, first thick, and then taper down to nothing but the oil.

HOW TO STONE IRON ROLLERS.

First put the roller in the lathe, and skim it up with a file, then take a piece of pummice stone, and hold it to the flutes for a reasonable time; next get a piece of oil stone and hold this to the flutes in the same way as the pummice. Rub well all over the roller with a bit of card filleting, and clean with hard waste and whiting.

Mason's patent long collar for slubbing, intermediate, and roving frames, is recognised in the trade to be a great improvement on the ordinary short collar. Its advantages are greater speed and steadiness, less wear and tear, and an improved production both as regards quality and quantity.

Many cotton main-driving ropes now working have stood the test of six years with the most satisfactory results. A two inch cotton rope will transmit 50 horse power, travelling 4,000 feet per minute.

In a 16 inch mule spindle, when spinning medium nos., the bevel is generally 4 in. The bevel in a 15 in., 15½ in., or 16½ in. is, of course, in proportion.

A 15 in. spindle should be 6½ in. out of bolster.
A 16 in. do. do. 7¼ in. do.
A 16½ in. do. do. 8 in. do.

Length and diameter of spindles.—

Slubbing	36 in.	x ¾ in.
Intermediate	32 in.	x 11/16 in.
Roving	30 in.	x ⅝ in.
Mule	16½ in.	x ¼ in.

If it is required to spin, say 36's weft, on twist mules that have been spinning, say 32's twist, the following alterations must be made:—

1st.—Close up the back and front plates a little, to shorten the bottom and the chase of the cop.

2nd.—Lower the boot-leg, to raise the faller, thus winding higher on the spindle.

3rd.—Turn the shaper rail screw up, by so doing the rail will drop and the faller will rise.

4th.—Change the shaper wheel to take two teeth at once, for the thickness of the cop.

5th.—Alter the back-change wheel to speed the carriage.

6th.—Knock the twist arrangement out of gear.

Whether or not, to turn the spindle bands must depend upon circumstances.

MULE (to doff).—

1. Stop mule when backing off.
2. Fasten under faller down.
3. Put cops up.

4. Wind quadrant chain down to bottom.
5. Turn shaper back.
6. Wind on spindle (stripping thread).
7. Doff.
8. For twist, turn winding chain up 5 or 6 turns.
   For weft, nothing—or a very little.
9. Put mule up to rollers, and then start off again.
10. Paste after 4 or 5 stretches.

At the commencement of a set, when the spindles are bare or empty, great care must be taken to set the copping rail and winding-on chain to their proper places; for if right then they will regulate themselves afterwards.

It is of great importance to have a thorough and regular system of oiling all the parts of every machine in the mill.

It is a good thing to black lead the "grids" in the scutcher, and the "cages" or under covers under the cards.

To find the Loss per cent. in Waste.

Weigh 100lbs. cotton, put it through blowers and carding engine; then weigh what is left, the difference is the loss % in *weight*, thus:—

No. 1.

Raw cotton	100lbs.
Cleaned do.	88lbs.
	12lbs. loss, or 12 °/o

No. 2.

Loss in money—12 °/o.

100lbs. cotton	at 6d. per lb.		£2	10	0
88lbs.	do.	cleaned	2	10	0

£2 10 0.
20
——
50
12
——
88)600(6·82d. per lb. cleaned.
528
——
720
704
——
160
——

No. 3.

100
12 loss.
—
88 : 6d. : : 100
100
——
88)600(6·82d.
528
——
720
704
——
160
——

Recipe for Varnish.

3 pints Acetic Acid.
½ lb. Venetian Red.
1 oz. Origanam.
1 lb. Fish Glue.

Break the glue in small pieces, put in a jar, pour on acetic acid, and stir occasionally for 24 hours.

Rollers must be sandpapered before varnishing.

The best mixture for fastening comber cylinders in is, block tin 12lbs. to pure lead 10½lbs. A special fluid is also used for this purpose, which is called Baker's soldering solution. There should be no difficulty whatever in fastening the needles in, unless the comber strips are not well cleaned from all grease and impurities before re-needling, which is a point that should have very careful attention.

Needle Pointed Cards.

Before starting grind light, say four days, then burnish one day, then grind again one day, or until card is true; second grinding very light.

Burnishing brush to be set in wire $\frac{3}{32}$ sec. on cylinders and tops, and doffer wire $\frac{1}{16}''$.

One card tops to be burnished every day, one brush to six cards to get round once a week.

Burnish cylinder and doffer one hour per week.

For one month strip three times a day, and then regulate grinding and stripping to circumstances.

TIME OCCUPIED IN THE ERECTION OF DIFFERENT MACHINES.

With adequate labourers' assistance, one fitter should erect one opener in five days; one single scutcher and lap machine in four days; three carding engines per week, providing he has not to wait for grinding or clothing; one comber per week; one drawing-frame in four days; one slubber, one intermediate, one rover, and one jack frame each in a week's time; and one pair of mules in three weeks.

It will, of course, be understood from the above that it takes a week to erect a slubber, another week to fit up an intermediate frame, one week to fit up a rover, and another week to set up a jack frame

A manufacturer is invited almost every day to make this or that change in his steam plant for the purpose of reducing his running expenses, or more often to reduce his coal bill for the production of a certain amount of power. The question for him to consider is whether it will pay him to make the suggested change or addition. In order to do this there should be readily seen a saving that will amount to at least a payment of 20 per cent. upon the investment he is making in buying the new device or arrangement. A manufacturer must lay out a certain amount of money for the apparatus that is going to effect the saving, and upon this amount he certainly wants a return of 10 per cent. for the use of the money besides the saving. If a device that costs 2,000 dols. will only effect a saving of 200 dols., or 10 per cent., there would be no gain in putting it in, for the money might be used in the business and make this return, and every manufacturer expects it will do so. There is to be added to this the depreciation and repairs and attendance of the new device and taxes that will make it necessary to save 300 dols. a year to get out clear, and this only leaves 5 per cent. as the additional profit that the device will give. The device should pay for itself then in five years to make it a profitable investment, and if it does not do so fails of its purpose, and has not sufficient recommendation of saving to induce the manufacturer to purchase and use it.

EXHAUST FANS IN MILLS.

The use of exhaust fans in mills where large numbers of hands are employed is becoming so general that a few lines on the subject cannot be out of place here.

The primary requirement of an exhaust fan is to move air in large or small quantities, according to the necessities of the room in which it is placed.

They may be used to inject fresh air or eject foul air.

There are many advantages derived from their use, and one, if not the greatest, is the effect their use has on the operatives. In a room fitted with fans enough to change the air every thirty minutes, the percentage of sickness is so low that the loss caused by absent hands is reduced to a minimum.

The temperature of any room may be held at a required point, provided the required point is not below the normal temperature out of doors.

By changing the air every few minutes in a bleach or dye house, the atmosphere is kept clear and the work greatly facilitated. In a card room, by drawing the air to one point and discharging it at that point, the dust is removed to such an extent that sweeping down is only necessary at long intervals. The result is the same in a mule room.

In a twisting room where the moisture is so great that the floor is continually wet, exhaust fans will remove that moisture in part, or, if required, wholly.

There are good, bad, and indifferent fans manufactured and offered for sale. Nearly all have some fault; either they use too much power, are not durable, are noisy, or are so constructed that they form eddies of air within themselves, and give a very small equivalent in air moved for the power used.

A fan should be strong and rigid. It should have large self-oiling bearings, and have the blades so pitched and formed that all back drafts or eddies are avoided. Fans larger than four feet in diameter should not be used for the reason that in very large fans the number of revolutions per minute must of necessity be small, so that the centre of the fan, or all that part near the axis, travels so slowly that it is practically dead and useless.

For example, in an eight-foot fan you have at 250 revolutions per minute a peripheral speed of about 6,300 feet per minute, but the speed at which the blades travel at an 18-inch radius is only about 2,362 feet per minute, which is too slow to be effective, no matter what the pitch of the blades may be.

The Seymour Patent Exhaust Fan, made in Newark, N.J., U.S.A., cannot be too highly spoken of as a well-made and most effective fan.

WEAVING.

Power looms have been brought to such great perfection that it is now both possible and profitable to produce almost any kind of textile fabric on them. In these pages a few hints will be given on the management of weaving mills, and on the art of managing the patent power loom.

In weaving, it is as equally necessary and essential to have good yarn, as it is in spinning to have good cotton. If the yarn be of a good or fair quality, the cloth, as a natural consequence, will likewise be of a good quality, and will therefore command a good price, and take a leading place in the market. There will be no occasion to hawk it about; but, on the contrary, it will be eagerly sought after. The production will be far greater than when using an inferior quality of yarn, and the waste made all through, both at the winding, warping, slashing, and weaving, will be considerably less. As a consequence of good weaving and extra production, the hands will make more money and be better satisfied, and this will result in bringing together or securing a better class of workpeople all through the establishment.

In the management of a weaving mill, the main thing is to keep ahead with both the production and quality of the cloth. By looking well after the machinery, and seeing that everything is in first-class working order, and by keeping the hands up to the work, the production will be good; the quality likewise depends upon these points, taken in conjunction with a fair yarn and good sizing. The waste made in a weaving mill is a very serious item, and should be strictly watched so as to be kept down as much as possible, and within reasonable limits. The winders' waste should be carefully examined and weighed-in regularly every day, and the weavers should be made to run off the cop bottoms as low as possible. It is equally necessary, and likewise of the greatest importance, to keep down the cost of production. This will be accomplished by the exercise of careful and wise economy. Any false economy, however, such as the use of inferior articles—strapping, pickers, etc.—should be strictly avoided.

WINDING.

The winding frame is a very simple machine, and needs no particular explanation. The spindles on either side are driven by bands from the tin roller which extends the whole length of the frame. For the traverse motion, there is a small pinion which drives the mangle wheel, the teeth of which are so contrived that the pinion works on both sides. When the mangle wheel has moved round a certain length, the pinion, by shifting to the opposite side, draws it as much in the contrary direction, and the wheel being fixed on the end of the shaft, which raises and depresses the bobbin rail or traverse motion, by means of the pinion acting into the rack, the alternate movement of the mangle wheel causes a constant alternate ascending and descending motion of the bobbin rail or traverse. In winding throstle yarn, the full throstle bobbins are put on the small spindles which run in a step and collar; when the yarn is winding the spindles run round with the bobbin; the thread passes through a brush and over a woollen cloth, which acts as a drag and likewise cleans the yarn. The guide wire consists of a thin plate of iron, the slit in the iron plate, through which each thread passes, is made like an arrow, with a slit on each side of the main slit; if the winder attempts to lift the end up it slips into either one or other of these slits, so that she is obliged to break the thread and knot it anew. In the old arrangement, with only one slit, it was easy for the winder to lift the thread out of the slit, when stopped by a bad piecing or a bad end, and allow it to pass. The slit also, as the yarn passes through it, helps to clear the yarn of shell and dirt.

The machine for winding mule yarn is of the same construction, except that the cops are put on skewers; the skewers are fitted into a small step, and stand in a slanting position, and the yarn in being wound on the warper's bobbins is passed round the flannel and through a brush, which also in this instance acts as a drag and clears the yarn. The guide is the same as described above, and the yarn in passing through the slits is guided to the bobbins, and considerably cleared of impurities, etc. If the yarn does not run off to the very bottom, as frequently happens, the skewer is put in a horizontal position, and allowed to run in centres, and at the same time free and steady. It is well to have three or four spindles so running for each winder, and by putting larger wharves on the bobbin spindles to run them at about half the speed of the other spindles.

In winding yarn from the hank swifts are used.

BEAMING.

The creel of the beaming frame is of a V shape, and care should be taken to have an equal quantity of bobbins in each half or side of the creel, so that there will be an equal quantity of yarn on each side of the beam from its centre, otherwise the yarn will be badly warped. The yarn in beaming passes through the reed, round the measuring roller, and under the rods—there are generally five of these rods, and they are for taking up the slack yarn as the beamer runs back the beam to find a broken end—on to the winder beam; this beam should be equally weighted at both ends, so that the yarn will build hard and equal. Care should be taken to set the measuring apparatus at its proper place before commencing to run the beam. All being in order, and the beam running, it is the warper's duty to watch when an end breaks, stop the machine, and draw it in. There is also a patent stop motion for stopping the frame when an end breaks. Each end or thread passes through a wire eye, which is supported by the end in its position; and when the end breaks it drops and comes into contact with a lever which is moving under the needles, and the belt is shifted from the fast to the loose pulley, when the frame stops.

The use of the fly wheel is to stop the frame gradually, otherwise the bobbins in the creels would overrun themselves.

The beamer should look well after her work, and take out all bad or soft ends; and when an end breaks, in piecing it up and drawing it in, she should be careful not to cross it.

REELING.

The reel is a very simple machine, and the reeling process is likewise very simple. The machine itself consists of a light framework; a row of small spindles, upon which the throstle bobbins run; the traverse; and the swift upon which the yarn is reeled. The swift is 54 inches in circumference, 80 revolutions of which make one lea or 120 yards; this is the first shift made on the reel, and seven of these shifts make one hank or 840 yards. The reeler's duty is to replace, as they run off, the empty throstle-bobbins by full ones; to piece up any broken ends, and in doing so to be very careful not to get the threads crossed or entangled one with another; to put in the yarn, and keep each lea separate and distinct; and lastly, her duty is to doff. The reeled yarn is put up into, say, 10lb. bundles, when it will easily be seen, by counting the hanks in the bundle, whether or not the proper counts of yarn are given, by multiplying the weight of the bundle by the number of hanks it contains; for instance, a 10lb. bundle of 32's should contain 320 hanks, because 32 x 10 = 320.

When the yarn is made up in the bundle, the proper length is given; but no more than the weight in lbs., in fact the pure yarn given in a 10lb. bundle is generally 9lb. 14ozs. Every knot (a knot contains 10 hanks) is weighed separately on a quadrant, and when spinning, say 32's twist, all the knots of exact 32's are, of course, bundled: the knots of 31's and the knots of 33's are mixed in equal quantities, and therefore come out 32's, and they in their turn are bundled the same as the exact 32's. In spinning, it is impossible always to keep the yarn exact counts; sometimes it gets on the heavy side, and at other times on the light side; when this is the case, and if the yarn comes in heavy, it is necessary to spin a quantity of light; or if the yarn comes in light it is necessary to spin a quantity of heavy; the light and heavy are then mixed in equal quantities—as already stated—to make them average right counts and weight.

SIZING.

This is the most important department in a weaving mill, and in importance may be compared to the mixing room of the spinning mill. The whole process of sizing or slashing requires the very greatest care and attention, for unless the twist be well and nicely sized it cannot possibly weave well. Any carelessness in this department will result in great loss. The right number of warpers' beams are placed at the back of the tape frame, in such a manner as to allow the yarn on the beam next to the machine to unwind from the top, the second beam from the bottom, the third from the top, the fourth from the bottom, and so on alternately from top and bottom, according to the number of beams being slashed or taped. The yarn is warped on these beams as wide as possible, so as to give it the greatest power of drying. The yarn from these beams passes through the boiling size in the size box, between the calender rollers, and round the copper cylinder, which is charged with steam; it next passes under and over the fans, and is wound on to the front or weaver's beam, properly sized and dried. It is better not to subject the yarn to too much steam or cylinder drying; it is far preferable to introduce more fans for the purpose of drying the yarn, which will thus be less liable to get burnt or hardened, and will retain both its nature and the size far better. The weaving is thereby greatly improved, as also are the yarn and cloth.

The quantity and strength of the size to be put on to yarn depends upon circumstances, and can only be regulated by experience; but when this is once determined upon, the taper himself must look after and keep the temper of the size regular and at one thing. The twist should not be allowed to go on to the weaver's beam until it is nicely dried. When the frame is standing, the yarn should be taken out of the boiling size; otherwise the ends will all get glued together. To do this, it is simply necessary to wind the roller that keeps the yarn submerged out of the size box.

When working fine reeds, or if the yarn is not up to the mark, the rods which keep the ends clear and separate should be changed at every beam; otherwise the ends get crossed and entangled. If the yarn is of good quality, and when working coarse reeds, these rods do not require changing so often. For 5 beams there are 4 rods; for 6 beams 5 rods; for 7 beams 6 rods, and so on. If the selvedges are made from doubled twist, they must be kept separate by a separate and distinct rod of their own. The speed of the machine is regulated by the cone drums, and the yarn is thus made to run quicker or slower according to the requirements of drying it. When all is properly set about the machine, and it is running nicely, the taper has to move about with his eyes on his work, to piece any broken ends, and to see that the yarn is properly sized and dried.

MIXINGS.

MIXING FOR 8¼LBS. SHIRTINGS. 32's TWIST; 32's WEFT.—3¾lbs. twist, 3¼lbs. weft, 1¼lbs. size = 8¼lbs.

1 pack (240lbs.) best white flour.
16lbs. best Russian tallow.
4lbs. best white soap.
Fomenting degrees 35 to 40.
To twaddle for usage 16 or 17 degrees.
Boiling at 212 degrees in the size box.

For preparing this size, the best and most approved system is to have four large square bins, with two agitators in each bin. The flour and water are mixed cold in the first bin to 35 or 40 degrees of density, and this must be allowed to stand for three or four weeks, until it becomes *perfectly sour;* after which, run off a certain amount into the second bin, and at once refill the first bin with the exact amount run off, again bringing the mixture in this first bin to the original strength, and so on to the last bin, reducing the strength to 30° in the second bin, 25° in the third bin, and 17° in the last or fourth bin, running so much out of one bin into the next, and regularly refilling as run off, in exactly the same proportion. The first is the fomenting bin, where the flour and water are mixed cold to 35° or 40° of density or strength: the second is the washing bin, and receives the mixture of flour and water in a cold sour state from bin No. 1; it must now be reduced in this No. 2 bin to 30 degrees. The mixture is now washed in the following manner:—When the agitators are standing, the flour settles to the bottom, the water remains of course at the top and gathers all the light dirt and impurities; after standing a time, this dirty water is run off and carries away all undesirable matter; the proper amount of fresh water is again run in, and the agitators are once more set to work. The third bin receives its share of the clean cold mixture of flour and water, which is now reduced or brought down to 25 degrees. This is next run into the fourth bin, and again further reduced to the right strength, say 16 or 17 degrees. It is now boiled at 212° through the introduction of steam. Into this is run the prepared or boiled tallow or soap, thus completing the mixing, which is at length pumped through 1½ or 2 inch pipes into the tape frame size box. The tallow and soap are boiled or prepared in a small boiler above the fourth bin, or in a separate tub, as most convenient. The finished size, in the size box, at the tape frame, must be kept *well boiling* through the injection of steam.

SUNDRY MIXINGS.

For 30's/40's twist, and 50's weft—

80lbs. Farina
4lbs. Tallow
2lbs. Wax
To twaddle 3½°

——

240lbs. Flour
10lbs. Tallow
To twaddle 6°

——

224lbs. Farina
2lbs. Tallow
3lbs. Wax
To twaddle 3½°

1 Sack Farina
2 lbs. Tallow
30lbs. Flour
4lbs. Wax
To twaddle 3½°

——

140lbs. Flour
224lbs. Farina
12lbs. Tallow
4 Buckets of China Clay and Antiseptic
To twaddle 3½°

For heavy goods, say 30's twist.—Boil 3 bags of China clay, 100lbs. of antiseptic, and 50lbs. of tallow, mix with 3 buckets of flour and farina. This mixing will work well.

For 30's/60's twist, and 40's/90's weft.—Mix to 25 gallons of water, 40lbs. of sago, and 40lbs. of farina, 4lbs. of tallow, 1½lbs. of best white soap or soft soap, and 1lb. of wax.

The general average is 1 gallon of water to 1lb. of farina.

Mixing for plain calico, 34's twist, 38's weft; 18 x 17; 72's reed:—

36lbs. potato flour
1lb. best tallow
2lbs. soft or white soap
2lbs. glycerine.

The tallow, soap, and glycerine to be mixed with 72lbs. of water, after which this and the flour all to be boiled together to the required strength.

Mixing for 60's twist; 100 reed, 35 picks.—

10 gallons of water
14lbs. farina
1½lbs. tallow
1lb. wax
To twaddle 6°.

Another.
140lbs. flour
112lbs. farina
5lbs. tallow
2lbs. cocoanut oil.
To twaddle 6°.

DRAWING-IN.

The weaver's beam has next to be drawn-in or through the healds and reed. The beam is fixed or hung up in a wooden framing, some five feet from the floor, and a sufficient length of yarn is turned off, so as to allow the end of it to come down to the drawer-in, who sits on a stool, with the healds and reed before him. The warp being spread out to its proper width, and the ends being separated with the comb put in by the taper, the reacher-in, who also sits on a small stool at the back of the beam, takes the threads one by one, and holds or hands them to the drawer-in, who draws them two at a time through the eyes of the healds and through the dent of the reed; one end or thread through each heald, and two ends through a dent. The ends are drawn-in in regular succession one after another from left to right of the beam. The beam is now ready for the loom, and is called a weaver's beam. Great care should be taken by the drawer-in so as not to get the ends crossed or entangled, otherwise they will give much trouble in weaving.

TWISTING.

Twisting as a rule is performed by young men. When new healds are not required, and when working the same class of goods, or rather weaving the same cloth, beam after beam, it is not necessary to re-draw-in the warp, but it is twisted-in. The healds and reed as they come from the loom with the yarn in them, are hung up in the twisting frame, opposite the new beam. The twister puts a piece of rope round the pulley, on the beam end, and hangs a weight to the end of it. He then takes a portion of the yarn, and fixes it to a hook fastened to a cord, which cord or strap goes round his waist, with the hook hanging to the cord at the front of his body. After he has brushed out the yarn, and made the ends straight, he begins to twist the ends of the warp to the ends that are in the healds and reed. He picks out the yarn from the warp with his right hand, and twists with his left.

THE LOOM.

THE DRIVING PULLEYS are fixed on the end of the top or main shaft of the loom; there are two of them. One, the fast pulley, gives motion to the loom; the other is the loose pulley on which the strap runs when the loom is standing.

THE CRANK SHAFT.—The lathe or slay receives its motion from this shaft by means of the connection rods; the bottom shaft likewise receives its motion from this shaft, through a range of wheels driven by the wheel on the out end of the shaft.

THE CONNECTING RODS.—These two rods are attached at one end to the crank shaft, and at the other end to the lathe or slay swoards.

THE BOTTOM SHAFT is driven from the crank shaft, and makes only one revolution for the crank shaft two; the healds and the picking motion are worked from this shaft.

THE YARN BEAM consists of a round piece of wood, with iron flanges on either end. This beam when filled with yarn is called the weaver's beam. It stands at the back of the loom, and when fixed in its place ready for working, a rope is passed twice or thrice round either neck, to which rope is attached a lever and weight to keep the beam steady.

THE CLOTH BEAM is the beam or roller at the front of the loom, upon which the newly-woven cloth is wound.

THE SLAY SWOARDS, SLAY, AND ROCKING SHAFT.—The slay swoards are fixed at one end to the slay, and their other end is fixed to the rocking shaft, which stretches across the loom near the floor. The slay is fastened to the upper ends of the swoards, and the race of the slay in the bevelled piece of wood upon which the shuttle runs when travelling across the loom. The top shell is that part of the slay which holds the reed by the top rim; the bottom rim of the reed is placed—in loose reed looms—between the strip and the back of the lathe.

THE BREAST BEAM is an iron plate at the front of the loom, over which the newly-woven cloth passes on its way to the cloth beam. An iron rod is fixed to the breast beam, and on this rod the self-acting temples are fixed.

THE PICKING SHAFT.—On the top end of this shaft is the picking stick, and on the bottom end the bowl. The picking scroll on the bottom shaft strikes against this bowl, and thus gives motion to the shuttles.

THE REED.

The reed is a very important article in weaving; it both divides the warp threads, and determines the fineness of the cloth; a coarse cloth, however, may be made in a fine reed, and a fine cloth may be made in a coarse reed; the number of threads or ends contained in a given space—say one inch—determines the fineness of the cloth. It is a general thing to put two threads or ends in a dent, and when speaking about the fineness of a piece of cloth, it is taken for granted, or understood, that there are two ends in a dent. The reed is rated by the number of dents to the inch. The magnifying glass, for counting the number of ends to the inch, is made with squares of ¼ and ½ inch. If the ½in. glass is used, and 24 threads are seen, it is called a 48; or if 36 threads are seen, it is called a 72, and so on.

The length of yarn to make a piece varies with the picks and counts of weft put in; ·02 per lb. should cover the waste in twist, and ·05 per lb. in weft.

Counts per ¼ inch.	Reed counts per inch.
12	44
13	48
14	52
15	56
16	60
17	64
18	68
19	70
20	74
21	78
22	82
23	86
24	90
25	94
26	98

The reed space of a power loom is from the weft grate on one side to the back board on the other side. A 26in. loom has 30 inches reed space. The scale from a 30in. loom to a 60in. loom is 5 inches, and above a 60in. loom 6 inches.

A 60's Manchester and Stockport reed has 30 dents in one inch;—this reed is equal to a Bolton 36's, or a full 67's Blackburn.

CONTRACTION.—The general contraction is about 2¼ inches in the cloth; consequently the yarn must stand about 2¼ inches wider in the reed than in the cloth.

MILLING-UP.—In plain goods, the general rule for "milling-up" is 1 yard in 20 yards. This, however, is more according to circumstances; it varies as the counts of twist and weft differ from medium counts, and with the number of picks put in the cloth.

MAKING OF CLOTH.

To make a good cloth is, of course, the most essential point in weaving; every effort should therefore be brought to bear with this object in view. To attain this end the following are the three most important items to be considered:—First, to make an even cloth; second, to put a good cover on the cloth; and third, to make good edges.

UNEVEN CLOTH.—There are many things which make the cloth uneven. If the yarn does not come off the beam regularly the cloth will be uneven. This may be caused through the weight ropes being damp, in which case they should be replaced by dry ones. Sometimes the collars upon which the weight ropes work become rusty, and if so, they and the ropes should be well rubbed with blacklead. If the weights touch the floor, or the beam necks be loose, the cloth will be uneven. If the neck of the emery roller be loose, or the wheel on the neck loose, the cloth will be uneven. If the cloth beam or emery roller be crooked the cloth will be uneven. If the pivots be strained the cloth will be uneven. If the wheels are not deep enough in gear they will slip back, and the cloth will be uneven; or if they are too deep in gear, and bind, or if the taking-up catch sometimes takes up two teeth, and at other times one tooth, the cloth will be uneven. If the flanges of the beam touch the roller or bearer, if the springs of the cloth beam are too weak, or the weights too light, the cloth will be uneven. If the finger at the end of the breast beam be set too near the fork lever, and will not let the catch drop so as to catch the teeth of the wheel, it will cause the cloth to be uneven. When the crank is on the front centre with the reed touching the cloth, the catches ought to be set so that the taking-up catch will drop off the tooth; when the crank is on the back centre, the holding catch should drop clear of the tooth. If the taking-up catch takes up two teeth at once, lower the stud or monkey tail, which is screwed to the lathe sword; if it does not take up one raise it. The foregoing are the main things which cause the loom to weave uneven cloth.

To put a good cover on Cloth.

In the making of good cloth this is one of the most important and necessary points to be attended to; at the same time it is one of the most simple and easy things to attain.

If the tapits tread too late the loom will make bare cloth, therefore see that they do not tread too late; raise the bearer, and tie the rods further back; if it is a heavy cloth set the lathe lower, and draw the lathe to which the lathe swoards are attached somewhat nearer the front of the loom, this has a great tendency to throw the fibres on the top of the cloth, and thus produce a full downy material. In a word, to put a good cover on the cloth it is necessary to both pick and tread soon.

It is very important to prevent cracks or thin places in the cloth when setting the loom on; this is a difficult job, especially when making light cloth, and on the loose reed loom. The best preventive of this is to have everything about the loom in first-class working order, and all nuts and bolts screwed up tight. All stopping and starting should be performed rapidly, and with precision; the crank arms should be tight, so as not to skake the lathe, and the strip that keeps in the reed at the back of the lathe must fit properly to the reed balk. Cracks in cloth may to a great extent be avoided if the weaver understands the proper conditions necessary for stopping and starting the loom, when taking-in the broken threads, etc. A thoughtful weaver, by attention to the skewering of cops, seeing to the shuttle pegs being the right thickness, the peg to be firm and fast, pointing direct to the shuttle eye, no part of the cop to project above or below the shuttle, seeing there is no cutting of weft in the shuttle boxes, weft grate, temples, or reed, etc., and starting the loom properly, will have few cracks compared with the indifferent weaver, who neglects these conditions. If the fulcrum of the taking-up lever be at the top of the loom it will be liable to make cracks, because it takes-up when the slay is at front-centre; the tension of the warp being easy allows the catch sometimes to take a tooth, whereas if the catch were at the top of the lever the conditions would be reversed, the most strain being on the warp when it is taking up at back-centre tends to prevent a tooth going after the weft comes off. Should the weft break when the shuttle is at the fork side, the weft lever is pulled off, suspending the taking-up, and extra picks are not required. Should the weft break and catch hold of the side, and the trail of weft be sufficient to lift the weft fork a number of picks, then extra picks are required. The weaver's judgment being required to adjust the loom before starting, it is very difficult to prevent cracks altogether with the present system of weft fork.

HOW TO MAKE GOOD EDGES OR SIDES, AND HOW TO MAKE THEM WEAVE WELL.

TO MAKE GOOD EDGES the yarn must be drawn in rightly at the sides, and the sheds must be set right. The shuttle must not rebound in the box, nor must the weft come off too freely; this (the weft coming off too freely) may be remedied or avoided by glueing a small piece of flannel in the eye of the shuttle, which will act as a drag on the weft. If the loom picks at its proper time, and picks strong enough, and the tapits be set correctly, the edges of the cloth will be good.

TO MAKE THE SIDES WEAVE WELL the temples must hold out the cloth to its proper width, and must be in good working order; one side must not be tighter than the other. The pickers also must be good and in good condition. If the picker is broken it will cause the shuttle to break the sides of the cloth; if the shuttle tip has worn a hole away from the right centre of the picker it will cut the sides; if the reed is broken, the healds badly pieced, or the twist be not right in the rods, healds, or reed, the sides will break. Care also should be taken to have the sheds equal, and to have the healds the proper height.

Give attention to the above and the sides will weave well.

GATING A LOOM.

Looms are generally set out in groups of four or six, and are thus nicely arranged in their places for either two, three, or four-loom weavers. When the loom is in its proper place, *i.e.*, where it is intended to stand and work, the first thing to be done is to square, level, and fasten it firmly down. Now put on the heald roller straps, check straps, and springs, pickers, and picking straps, etc.; fit the shuttles to the shuttle boxes, and put in the reed; next see that the loom picks at the proper time, and with just enough force to drive the shuttle across the cloth into the opposite box, neither too hard nor too easy. Lastly, set the temples, treading tapits, and weft fork as described later on; also set the taking-up motion to take one tooth at a time. Screw up tight all the nuts and bolts, oil the loom well, put on the driving-strap, and run the loom a few hours to see that all is right before putting in the warp; after which put in the warp, gate it carefully, and commence weaving.

GATING THE WARP.

Gating the warp is a very important matter; for unless this is well done, it is impossible to make good cloth or make the warp weave well. The loom should be well examined before the warp is put in, to attend to whatever repairs may be wanted, and to screw up whatever may have come loose. Now, also, is the time to give the loom a thorough good cleaning and oiling. After putting the warp in the loom, lay in the lap, and put on the weight ropes and weights, put to the top (heald) cords and make them all of one length; the heald roller straps should likewise be of one length; fasten to the bottom cords, and see that the healds are not too high or too low, and make the sheds perfectly equal, and of a medium size. If the sheds are too large the cloth will be bare, and the shuttle will strike against the spindle-studs, and so get worn, and splinter, and be liable to break the yarn and cause smashes. The front stave should rise when the loom picks from the left-hand side of a right-hand loom, and from the right-hand side of a left-hand loom. If the shuttle picks under the twist the healds are too high, and if over the twist the healds are too low, unless the loom is picking too soon or too late. If the above be attended to the healds will work smoothly and easily, and the warp, if all else about the loom is right, is sure to weave well.

THE LATHE OR SLAY.

The lathe is one of the most important parts of a loom, and it should be well and accurately set to make the loom weave well. When the crank is on the top centre, the lathe swoards must be set so as to stand 2¼ or 2½ inches nearer the front of the loom at the bottom than at the top; the lathe must be set level, and the raceboard about 1 inch below the breast plate, on the loom front. In fast reed-looms, the stop-rod blades should fit to the frogs in a dovetail fashion, so that when the loom bangs they will not fly over the frogs. When the loom is working, the fingers on the stop-rod should be set so as to cause the blades of the stop-rod to clear the frogs, and the fingers should have ¼ of an inch play from the swell when the shuttle is in the box; the spring that holds the stop-rod down should not be too tight. The fingers should be screwed fast to the stop-rod, and the steps in which the stop-rod works should be kept clean and well oiled, so that it may work freely and easily.

In loose-reed looms when the crank is on the top centre, the lathe swoards should be set from 2¼ to 2½ inches nearer the front of the loom at the bottom than at the top of the swoard; the lathe must be set level, and the race-board about an inch below the breast-plate on the loom front. The fingers under the lathe are to make the reed fast when it touches the cloth, and should be so set as to go under the brackets which are fixed to the breast plate, from ¼ to ½ an inch; they should be set as fine as possible, but so that they will get under the bracket and not over; the reed will thus be firmer when it strikes the cloth. All the springs that are in connection with the reed should be tight, so as to keep the reed perfectly steady when the loom is working; when the crank is on the top centre there should be two inches play between the spring that holds the reed when the shuttle is working, and the brackets on the breast-plate, so that if the shuttle catches in the shed, it will throw the reed out. The rod which holds the strip that allows the reed to fly out is held by carriers and brackets to the lathe swoards, and these should be well and regularly cleaned and oiled, so that the rod will work free and easy.

THE WEFT FORK.

The weft fork is to make the loom stop when the weft is broken, and when weft runs off; also to prevent the loom from stopping when the weft is not broken. The weft fork must be set so as not to touch or come in contact with any part of the grate, but should have a clear road right through. If the fork touches any part of the grate, the loom will not knock off when the weft is broken, and on the other hand it will probably stop the loom when the weft is not broken. When the loom is running, the fork should go through the bars of the grate just far enough for the weft to lift the fork so high as to nicely clear itself from the hammer. When the loom is weaving, the weft fork to do its duty properly must be set so that it will touch nothing but the weft, and when the weft does not touch the fork the loom should stop. When the crank is on the front centre, and the reed is close up to the cloth, set the bowl on the weft tapit close to the weft lever, and if the lever is properly set it will stop the loom when the weft breaks; the weft lever and fork holder can be adjusted and regulated just as required, and to a very great nicety; all that is necessary to make the weft motion work well and accurately is simply a little study and patience.

There are many causes for the loom stopping when the weft is not broken, namely: if the fork does not go far enough through the grate; if the loom picks too late or too weak; if the shuttle rebound in the box, the weft will run slack and the loom will stop; if the fork has too much play, or be strained, touches the wires of the grate, or stands too high, the loom will stop when the weft is not broken, and not stop when the weft is broken; if the lathe has too much play at the bottom, and moves backwards and forwards, or swerves from one side to the other, it may stop the loom, or otherwise cause it not to stop; if the setting-on-rod be too weak, so that it springs backwards and forwards against the fork-holder when the loom is working, it will not stop when the weft is broken, etc., etc. There are innumerable other things which occur daily and cause the loom to stop and prevent it from stopping; these, however, will easily be found out and remedied upon examination.

THE PICKING MOTION.

When running from 180 to 200 picks a minute the loom should pick just before the crank gets on to the bottom centre. The loom can be made to pick either sooner or later, according to the settling of the boss to which the scroll is fastened. To give a nice easy pick set the point of the scroll as near as possible to the end of the bowl on the picking shaft; this bowl can be set according to the requirements of the case, and can be set higher or lower as needed. The scroll should be set to give the pick, say 1¼ inches, before the crank gets to the bottom centre. The picking motion, with a little care and judgment, can be set to a very great nicety, and in all cases should be so set as to give a gentle and easy pick.

THE TREADING TAPITS.

To put a good cover on the cloth, and make the yarn weave well, with as little strain on the healds as possible, it is of the first importance that the tapits be rightly set. One side of the tapit is about 5/16ths of an inch in diameter larger than the other, and this larger side is to tread the back shaft, as it is farther away from the reed; the least side is to tread the front shaft, which is of course nearest the reed. If the treadle tapits are set too late, the loom will make bare cloth; if too soon the shuttle will rattle as it enters the box. The tapits should be set perfectly level; that is, they should be set so that the treadles will be level when the crank is on the top centre.

THE TEMPLES.

The duty of the temples is to keep in the selvedge ends, and also by stretching out the cloth to keep it to its right width. They should be set so as to stand as near as possible to the reed without touching it; when the crank is on the front-centre, and about ¼ of an inch lower on the reed side than on the opposite side, and when the loom is working, they should be set as near the lathe bottom as possible without touching it.

There are several kinds of temples, but the trough and roller temple is most generally in use; one advantage it has is that it helps to throw the reed out when it catches in the shed; there is also a better cover got on the cloth with this temple. For heavy work the other, or side temples, are preferable, as they keep the cloth better stretched than the trough and roller temples do.

For light goods the lathe should be set a little higher, and the temples a little further from the reed.

THE TAKING-UP MOTION.

When the crank is at the front-centre the taking-up catch must be set so as to drop one tooth on the ratchet wheel, and when the crank is at the back-centre the holding catch must be so set that it will drop ⅛th of an inch over the ratchet wheel tooth; the monkey tail, which works the taking-up catch, must be set to take up one tooth at a time; all the taking-up wheels should be set just nicely in gear, deep enough and not too deep, so that they will not bind nor take up two teeth instead of one. If they are too deep in gear the teeth will be liable to break; if not deep enough they will slip backwards and forwards, and so cannot possibly take up uniformly. To make a regular cloth, everything about the taking-up motion must be set accurately, so that it will work smoothly and regularly. To put more or less picks in the cloth it is simply necessary to change the pinion. For more picks, or heavier, a less pinion; for less picks, or lighter, a larger pinion.

THE BREAK.

The break is to regulate the stopping of the loom, to prevent it from overrunning when the weft is broken or runs out, and also to stop the loom when the shuttle is at the fork side. If the break acts properly, the loom, when it stops, will not lose more than two picks. The loom should stop when the lathe is at the back; the weaver has then simply to take out the empty shuttle, put in another, and hold the holding catch finger until the loom has picked two or three times, so as to prevent irregularity in the cloth. Regulate the break by putting on more or less weight; if the loom loses more than two picks when the weft breaks or runs out, put on more breakage. If the loom is made to stop when the crank is just over the back-centre, it has a better chance of starting again in a proper manner. The setting-on of the loom is a very important matter; a little extra care on this head will prevent both cracks in the cloth and smashes.

SMASHES.

It is the duty of the weaver to keep his eyes open, and, by attending properly to his work, prevent smashes as far as possible. In loose reed looms, when the shuttle stops in the shed, the reed, if everything about it is in order, should fly out without breaking the twist. If the loom does make a smash, when the shuttle catches in the shed only, it may arise from some one of the following causes, namely:—If the reed does not fly out, the finger which is screwed to the stop-rod has probably caught hold before the shuttle forces out the reed. If the reed balk be too thick and it fits too tight, and will not go out easily, it will make a smash. If the springs at the back of the shuttle boxes be too strong, or if the spring which acts on the finger to keep in the reed be too strong, the reed cannot go out easily. There are other causes, such as the shuttles splintering or breaking, and many little things that can only be found out in practice; but if the reed be so set that it will, in case of any accident, fly out easily, smashes will be reduced to a minimum.

THE SHUTTLE FLYING OUT, TURNING OVER, OR RATTLING IN THE BOX, may and often does arise from one and the same cause, namely:—If the lathe stands higher at one side than the other; if the reed is broken or crooked; if the picker is broken; if the shuttle is round at the bottom; if the shuttle tip strikes the picker too high; if the loom picks too soon, too late, or too strong; if the healds are too high, or too low, etc., etc. There are many other causes, which will be found out in practice, and which to a practical eye are easily visible.

Cops knocking-off.—This may be caused by the loom picking too strong, by the shuttle peg being too small, or the top spring too weak, or by the weaver not skewering the cobs in a proper manner, etc., etc.

If a tackler is called to a loom and cannot at first find out what is wrong, or in other words gets fast, he will, upon closer examination, be sure to find out the cause which produces the effect.

Pickers and Strapping.

Pickers form a very serious and most important item in the wear and tear of a weaving shed, and unless they are of a good quality they soon become useless, and cause nothing but bad work, besides being a great hindrance to the weaver in keeping the loom at work. Much care is necessary in preparing the pickers, so as to make them durable and to get them in good working condition. Before using them they should be hung up in a dry but not too warm place for at least six weeks, after which they should be steeped in good Gallipoli oil for a month; they should then be hung up again and gradually dried for another six weeks; after which they will be ready for work, and if of a good quality will work well and satisfactorily.

The strapping (lever straps, check and picking straps, etc.) should likewise be of the best quality; it will last longer, give far less trouble, and altogether in the long run will prove more serviceable and economical than strapping of a poor or inferior quality.

CONCLUSION.

The plain calico loom is a very simple machine, and its mode of working may be easily understood by even the meanest capacity. To make it perform its work in a satisfactory manner all that is required may be summed up in the two words, care and attention. It would be useless to go on enumerating the scores of things that occur daily and prevent the loom, or the various motions, from working with precision and accuracy. If the loom be kept in good working order, clean, and well oiled, if everything be set right in its proper place, and screwed up tight, and if all and every motion work in unison one with another, the loom will run as a machine ought to do, and the numerous mishaps that—through carelessness—are so continually taking place, will seldom be heard of. When the loom does get out of order, or when any one of the motions requires the tackler's attention, he should at a glance be able to tell what is wrong; the cause as a rule will arise from some trifling thing which may be easily remedied on account of the simplicity of the whole machine, and everything in connection with it.

WEAVING CALCULATIONS.

To FIND THE WEIGHT OF YARN ON A BEAM.

Rule.—Multiply the length by the number of ends for a dividend; then multiply 840 (yards in a hank) by the counts, for a divisor; the quotient will be the lbs. of yarn.

Example.—How many lbs. of yarn on a beam 10,000 yds. long, 30's counts?

$$\frac{10{,}000 \text{ yds. x } 500 \text{ ends.}}{840 \text{ x } 30\text{'s counts}} = 198\ 4 \text{ lbs.}$$

To FIND THE LENGTH OF A WRAP ON A WARPING (BEAM) FRAME.

Rule—Multiply the number of teeth in the wrap wheel, stud wheel, and the number of inches in the circumference of the measuring roller together, and divide by 36 (inches in a yard) ; the quotient will be the number of yards in a wrap.

THE TAPE FRAME.—To FIND THE LENGTH OF YARN IN A MARK.

Rule.—Multiply the bell wheel, stud wheel and circumference of tin roller together, and divide by the tin roller wheel; the quotient will be the inches in a mark.

Example— 86 stud wheel.
40 bell wheel.

3440
15in. circumference tin roller.

17200
3440

Tin R. W. 100)51600

36)516(14yds. 12in. Ans.

To find the number of teeth in the tin roller wheel.

Rule.—Multiply the bell wheel (40), stud wheel (86), and circumference (15in.) of tin roller together, and divide by the inches in the mark; the quotient will be the tin roller wheel.

Example— 40
86

3440
15

Inches in mark—516)51600

100 Ans.

TO FIND THE STUD WHEEL.

Rule—Multiply the length (516) by the tin roller wheel (100), and divide by the circumference (15in.) of the tin roller multiplied by the bell wheel (40).

Example— 516
100

15 x 40 = 600)51600(86 Ans.

TO FIND THE BELL WHEEL.

Rule.—Multiply the length (516) by the tin roller wheel (100), and divide by the circumference (15in.) of the tin roller, multiplied by the stud wheel (86).

Example— 516
100

15 x 86 = 1290)51600(40 Ans.

TO FIND THE CIRCUMFERENCE OF THE TIN ROLLER.

Rule.—Multiply the length (516) by the tin roller wheel (100), and divide by the bell wheel (40), multiplied by the stud wheel.

Example— 516
100

40 x 86 = 3440)51600(15 Ans.
3440

17200
17200

If the stud wheel and the tin roller wheel contain the same number of teeth, the length of a mark will be the product of the circumference of the tin roller and bell wheel.

Example—15 x 40 = 600 ins. = $16\frac{3}{4}$ yds.

WHAT BELL WHEEL IS REQUIRED TO MARK AT 20YDS. WHEN THE TIN ROLLER WHEEL AND THE STUD WHEEL ARE ALIKE?

Rule.—Divide the inches in the length of the mark (720) by the circumference (15in.) of the tin roller; and the quotient will be the bell wheel.

Example— 20 x 36 = 720
15)720
48 Ans.

TO FIND THE DIVIDEND OF A POWER LOOM.

Rule.—Multiply the driven parts together for a dividend, and the driving parts together for a divisor; the quotient will be the mathematical dividend of the loom.

Example — Rack wheel, 50; beam wheel, 75; carrier wheel, 120; pinion, 15; and circumference of emery beam, 15 inches.

$\dfrac{50 \times 75 \times 120}{15 \times 60}$ 500 Mathematical dividend.
add 7 to meet contraction.
507 the practical dividend.

TO FIND A PULLEY TO PUT ON A LOOM TO GIVE ANY REQUIRED NUMBER OF PICKS PER MINUTE.

Rule.—Multiply the speed of the driving shaft per minute by the diameter of the drum on same; and divide by the picks wanted per minute. The quotient will be the diameter of the pulley to put on.

TO CHANGE FROM ONE NUMBER OF PICKS TO ANOTHER.

Multiply the pinion-on by the number of picks it is making for a dividend, and divide by the number of picks wanted; the quotient will be the change pinion required.

TO FIND THE PICKS PER INCH.

The rack wheel has 50 teeth; on the same arm is a pinion with 30 teeth, working into a carrier of 120 teeth; on the same stud is a 15-tooth wheel working into the 75-tooth beam wheel. Circumference of emery beam, 15 inches. Picks per inch required.

Multiply the 50 x 120 x 75 for a dividend; then multiply the 30 x 15 x 15 for a divisor. The quotient will be the picks per inch.

50	30
120	15
6000	450
75	15
450000	6750

6750)450000

66 Ans.

TO FIND THE WEIGHT OF TWIST CONTAINED IN A PIECE.

Rule.—Multiply the number of ends in the piece by the length of the cut, as delivered at the tape frame, for a dividend; then multiply the counts of the yarn by 840 for a divisor. The quotient will be the weight of twist in the piece.

TO FIND THE WEIGHT OF WEFT REQUIRED TO FILL A PIECE OF CLOTH.

Rule.—Multiply the picks per inch, the width of the piece at the reed, and the length of the piece in yards, for a dividend; then multiply 840 (the length of one hank) by the counts of the yarn for a divisor. The quotient will be the weight of weft required for the piece.

TO FIND THE COUNTS OF THE WEFT AND THE TWIST TO MAKE A PIECE OF CLOTH.

The calculation is the same as finding the weight of weft and twist, only use the weight of each wanted instead of the counts, and the answer will be the counts instead of the weight.

TO FIND THE WEIGHT OF 32'S YARN REQUIRED TO MAKE A PIECE 37½ YARDS LONG, 60'S REED AND 39IN. WIDE.

In this instance the yarn should stand two inches wider in the reed than the width of the cloth, and the yarn is taken as 31's.

Rule.—Multiply the length, counts of reed, and width in the reed together for a dividend. Multiply the yards in one hank by the hanks in a pound for a divisor. The quotient will be the weight of twist in the piece.

Example—

40	840
41	31
1640	840
60	2520
98400	26040

26040)98400(3·77
78120

202800
182280

205200

To find the counts of weft required to make the above piece 8¼ lbs. with 30% of size in it, and 15 picks to the quarter. First find the weight and twist and size; thus: 30 on 3·77
is 1·13

Twist and size 4·90

Then 8·25 − 4·90 = 3·35 weight of weft required. To find its counts.

Rule.—Multiply the length of the piece, picks per inch, and the width the yarn stands in the reed, together for a dividend. Divide by 840 (yards in one hank), multiplied by the weight of weft required; the quotient will be its counts.

Example—

$$\frac{60 \text{ x } 38\tfrac{1}{2} \text{ x } 41}{840 \text{ x } 3{\cdot}35} \quad \text{34's. Ans.}$$

RULES, ETC., HOW THE PRICES ARE RECKONED UP, TO SEE WHETHER YOU CAN AFFORD TO TAKE THE PRICE OFFERED FOR THE CLOTH

1. THE DIVIDEND FOR THE TWIST is got by multiplying the number of ends by the length of the cut, and dividing by 840 (the yards in a hank). The divy, divided by the counts, gives the weight.

2. THE DIVIDEND FOR THE WEFT.—The width of the warp in the reed, multiplied by the number of picks per inch, and by the length of the cut; divide this result by 840 (the yards in a hank). The divy, divided by the counts, gives the weight.

S.S.—Short Stick—36in. to the yard.

L.S.—Long Stick—37in. to the yard.

20yds. S.S. is taken at or as 19½yds. L.S.

Example— T W

Cloth 36in. wide; 20 yds. long S.S.; 12 x 12; 40's twist; 50's weft.

	Divy.	W'ht of yarn.	C'ts.	Price.	£	s.	d.
T.	45	1lb. 2oz.	40's	10d.	0	0	11¼
W.	48	15	50 s	10¼d.	0	0	9½
		2 1			0	1	8¾
Add 5% for waste, etc. (say)......					0	0	1
Weaving 4¾ doubled					0	0	9½
Cost of quoting price per piece					0	2	7¼

Examples how to get the Divy.

The Twist Divy.

12 x 12; *i.e.*, 12 ends to the ¼ inch or 48 ends to the inch. Therefore

```
        48 ends to the inch.
        38 inches wide at the reed (two inches
      ——         added for contraction).
      384
     144
     ———
     1824 ends in the piece.
        21yds length (1yd. added for milling-up).
     ———
     1824
    3648
    ———           Counts 40's)45
840)38304                      ———
    ———                   1 lb. 2oz. weight of
      45  Divy.                      twist in
    ———                              the piece.
```

The Weft Divy.

```
        48 ends to the inch.
        38½in. width at the reed (2½in. added
      ——          for contraction.)
       384
      144
        24
      ———
      1848
```

```
     1848
        21½yds. long (1½yds. added for milling-
     ----              up).
     1848
    3696
      924      Counts 50's)48
    -----               ---
 840)39732                  15oz. weight of weft
    -----                         in the piece.
 Divy 48
```

The length of yarn varies (to make a piece) as the picks and counts of weft put in.

The yarn should stand from 2 to 2¼ inches wider in the reed than in the cloth.

The contraction in the length of a piece is about one yard in 20 yards; but it also varies as the counts of twist and weft differ from medium counts, and as the number of picks put in.

The calculations, however, are the basework or standard upon which to work.

Another example—

19 REED 70.

wth.	l'gth.	square.									
in.	yds.	T.	W.	divy.	c'ts.	lb.	oz.	price.	£	s.	d.
36	37½	19 x	22	136	32T.	4	4	9¾	0	3	5½
				161	36W.	4	8	9¾	0	3	8
			Weight of piece,			8	12		0	7	1½
Add 5 % for waste &c. (say),									0	0	4¼
Price for weaving, 1/6¼ doubled									0	3	0½
Cost or quoting price per piece									0	10	6¼

The twist divy.

19 x 4 = 76 ends to the inch.
76 ends to the inch.
38 inches wide at the reed (2in. added for contraction).
2888
39½yds long (2yds. added for milling-up).
840)114076
136 Divy. 32's)136(4lbs. 4oz. weight of twist in the piece.

The weft divy.

88 ends to the in.(22 to the ¼in. x 4=88 to the in.
38½in. wide at the reed 2½in. added for contraction).
704
264
44
3388
40yds. long (2½yds. added for milling-up.
840)135520
161 Divy. Counts 36's)161
4lbs. 8oz. weight of weft in the piece.

In working out these divys and calculations, surrounding circumstances, state of trade, etc., must always be taken into account. It is necessary at times to give and take a little.

HOW TO GET THE NUMBER OF ENDS TO MAKE THE CLOTH A CERTAIN WIDTH, AND HOW TO FIND THE REED FOR SAME, ETC., ETC.

Take a piece 36 inches wide, 19 x 19 square. This cloth should stand say 2¼ inches wider in the reed than the woven cloth itself. 19 ends to the ¼ inch multiplied by four gives 76 ends to the inch; thus the cloth counts 76 ends to the inch—as seen through the glass when examined on the counter.

19 x 4 = 76 x 36 = 2736 ends in the piece.
38·25 inches at the reed.
71·50 reed.

2735 ends in 38¼in. at the reed with a 71½ reed.

If a 71½ reed gives 2735 ends, how many ends will a 70's reed give? Less, therefore.

As 71½ : 70 :: 2735
70
71·50)19155000(2679 ends. Ans.

Or 38·25 x 70 = 2577½ ends.

2736
2677
59
28 selvedge
87

Or 36 x 76 = 2736
28¼
36)103660(2879
2736
36)143(4 ends to the inch
144 contraction.

Or 36 x 70 = 2520		2736
143		36
——		——
2663		$38\frac{1}{4}$)10449600
28		——
59		2732
——	2677	4
2750	2663	——
14	——	2736
——	14	——
2736	——	
——		

If a 76 gives $38\frac{1}{4}$ what for 36in. ? Less, therefore.

As $38\frac{1}{4}$: 36 : : 76
36

——

38·25)2736·00($71\frac{1}{2}$

——

Again —

19 x 4 = 76 x 36 = 2736 2736
70 x $38\frac{1}{4}$ = 2677 2677

		——
59	2667	59 difference.
28	28 selvedge	28 selvedge.
—	——	—
87	2705	31 over.
	31	
	——	
	2736	
	——	

It is therefore seen that a 70's reed is required.

To find the reed—

2736 ends wanted or in the cut.

36

38¼)10449600

2732

Percentage of contraction—

As 36 : 38¼ : : 100

38¼

36)3825

106¼ or 6¼% contraction.

76 ends to the inch in the reed is really a 76 reed (the cloth standing in the reed 38¼ inches). The cloth when on the counter will measure 36in., thus milling-up 2¼in. or 6¼% ; therefore the reed required to give the exact number of ends for this price is—

76

6¼

456

19

100)475

76

4¾

4¾ less 71¼, so that a 70's reed will do or pass in this case.

FOR THE LENGTH, NUMBER OF BACK BEAMS, AND LENGTH REQUIRED FOR EACH BEAM.

An order for, say, 100 pieces, 100 yards long. 100 x 100 = 10,000 yards woven cloth.

If it will mill up one yard in twenty yards, how many yards will it mill up in 10,000 yards?

$$20 : 10{,}000 :: 1$$

$$\begin{array}{r} 1 \\ \hline 20)10{,}000 \\ \hline 500 \end{array}$$

It will mill up 500 yards in 10,000 yards; therefore you require 10,500 yards of yarn in length for these 100 pieces; in addition to which a further allowance must be made for waste—*i.e.*, for what remains on the warpers, tapers, and winders' beams. The general allowance is two yards to each finished taper's beam, or for every beam doffed at the tape frame, and also two yards extra to be allowed for the waste on each weaver's beam. It is likewise necessary to still further allow or add a little more for the length left on the tape frame, round the cylinder and between the rods, etc. Divide the total length of yarn by the number of beams required, and you get the right length to put on each warper's beam.

For the number of ends in each warper's beam, say 2736 ends in a piece of cloth 36in. wide, as above:

If 5 beams, 2736 ÷ 5 = 447 ends each per beam.
If 6 „ 2736 ÷ 6 = 456 „

according to the number of bobbins the creel will hold.

THE MANUFACTURE OF THREAD.

The manufacture of thread is a process of comparative ease and simplicity as compared with several other branches of cotton manufacture, such as spinning, fancy weaving, printing, or dyeing. The impression commonly held by those not acquainted with this particular branch of the art, that there is something very intricate and complicated about it, is quite erroneous; for both the actual process itself, and the machinery in use, are of a very elementary order.

Given good yarn, there should be no trouble or difficulty in making good thread, providing due and strict attention be paid to certain small details, such as even tension in winding, and the avoidance of slack bands in twisting.

To produce six-cord thread for sewing purposes, the following processes have to be gone through:—First, the yarn is wound (two ends together) on to what is called a winder's bobbin, in the doubling winding machine, after which it is twisted on the first twister (wet); it is next re-wound on to large bobbins in the re-winder, and then passes to the second twister (wet), in which machine three of these two-cord bobbins are doubled and twisted together as a cable; these bobbins are next taken to the reel, and are reeled off into hanks, which in this state are passed on to the examiner for inspection. After passing this necessary ordeal, the thread is dyed or bleached, and is then again subjected to the operation of winding on to larger bobbins at the hands of the hank-winder; these bobbins in turn are placed in the spooling machine, to be spooled or wound on to the small 200-yard spools of six-cord thread so well known in every household.

The winding, reeling, and twisting machinery of a mill is so well known to everyone engaged in cotton manufacture, and likewise is so simple in construction and working, that no detailed description is necessary.

DOUBLING is a very important and extensive branch of cotton manufacture, and whilst there are in different parts of the world many concerns where both spinning and doubling are carried on together, there are likewise very many establishments devoted to the doubling branch alone. Doubled yarns are in great demand for many and various purposes, such as for the lace and hosiery trades, for crochet, knitting and sewing purposes. In manufacturing various descriptions of silk, woollen, worsted, cotton or linen fabrics, the warp also consists of doubled yarn; there is, in fact, a wide and ever increasing field for doubled cotton yarns of all counts, from the coarsest to the finest numbers.

DOUBLING WINDING.—The all-important point in this process is, to see that the two ends which are being wound together as one are perfectly even in tension; otherwise, the resultant product will be defective, causing uneven and "corkscrewed" thread. In this machine the skewered cops are placed in brackets, the yarn to be wound first passing through the so-called knot-catcher—an adjustable slot, the width of which can be regulated to the counts and quality of the yarn being wound. The slot is set so as to catch all lumps or knots in the yarn, and thereby break down the defective end, thus preventing imperfect yarn from going forward to the twister.

The yarn, after passing through this slot, is drawn over the flannel-covered "drag-board." Here it is where the tension is applied, and where the drag is regulated, by altering the angle of the drag-board, so as to increase or decrease the tension as circumstances require.

The yarn next passes through the detector wire eye, when if an end breaks the bobbin upon which the yarn is being wound is through a simple and ingenious mechanical arrangement lifted away from its contact with the drum upon which it is running, thus preventing "single." After leaving the detector wire the yarn is carried up and over a small accurately cut and highly polished iron pulley, similar to a mule spindle wharve; around this it passes down through the guide wire on to the winding bobbin, which latter receives its motion through frictional or surface contact with the winding drum.

The traverse motion imparts the necessary reciprocal traverse to the guide wire, which guides the yarn out to the bobbin the right distance between the two flanges of the bobbin.

"Corkscrewed" thread is the inevitable result of uneven and irregular tension in either winding or twisting, as the slack end or thread will coil in an uneven spiral around the other end or thread. This "corkscrewing" is a fatal defect when true excellence is the desideratum, and will not exist in a well-regulated and well-looked-after mill.

When an end breaks in the winding, the winder should tie together the broken ends of each individual or single strand or thread so as to make as small a knot as possible. Knots in thread are a very great imperfection or drawback, especially so when the thread has to pass through the eye of a needle, as for lace, hosiery, or sewing purposes.

A little extra care and attention to the above small but important detail will be of great benefit. As the work of the winder is light, clean, and pleasant, accuracy and close attention should be insisted upon.

THE RE-WINDER as a machine is in every respect a fac-simile of the doubling winder, and the work performed by it is simply a repetition, at a later stage, of the work executed by the latter, and therefore needs no further explanation. The author must, however, point out the necessity of perfect and thorough cleanliness in manufacture, and in all the parts of every machine used in the whole process.

The question of cleanliness should be so thoroughly insisted upon as to be made the leading feature in the winding, twisting, and spooling departments of the mill, and no opportunity should ever be neglected of impressing upon the hands the importance of this matter.

THE RING DOUBLER OR TWISTER, chiefly on account of the heavy production it is capable of, with its attendant all-round economy, has completely out-stripped its several competitors, and is to-day almost universally regarded as the only twister of real practical and commercial value in the trade.

The function of this machine is merely one of twisting two or more ends together, the amount of twist to be introduced being determined by the particular requirements of the case—that is, whether the thread be for knitting, sewing, or other purpose.

The matter of twist is one in which the practice differs greatly in different mills, there being no arbitrary or established rule.

The best practice is to follow the principle laid down for obtaining the twist in spinning single yarns.

Yarns doubled on that principle will lie as straight as in the single state. Suppose 100's has to be doubled into two-fold, two threads of 100's being put together, the joint thread will be 50's; the square root of this number is 7·05, which, multiplied by 3¾ or 3·75, gives 26·43 for twist. If the double yarn be wanted of a soft texture, the square root as obtained above should be multiplied by 3¼ when the twist will be such as will set without curl. When curl is required an additional percentage to the above twist must be put in; in all cases the twist should be put in in the direction opposite to that of the last preceding process. Suppose three strands of this 100/2-fold be laid together and it is wanted to know the proper twist to put into the six cord which it has thus become, let it be assumed that the operation was commenced with yarn of true counts, that is 100's; the doubling makes this into 100's two-fold, or counted singly 50's. But if measured and weighed out, this yarn would not contain more than 48 hanks to the pound, and the reason of this is that the twining of the threads together reduces the length by about two hanks.

Hence it is necessary, when a true length is required, to start with yarn higher in the actual than in the nominal counts. The three strands of the two-fold hundreds (100's) having, as we have seen, become not 50's, but 48's, three of these laid together now reduce the counts to 16's. The square root of this number is four, which multiplied by 3·75 gives 15—the number of turns per inch required at this stage. This process, followed throughout, will give satisfactory results. When the yarn is wanted to curl, it is usual to add about twenty per cent. to the twine obtained by this principle. For knitting-yarns of three folds, which are required to be soft, a rule in extensive use is, to multiply the square roots of the yarns (single) by 2¼, and the result is the turns required. Crochet yarns follow the same rule, but require two for a multiplier. Embroidery cottons (four-fold) use the same standard as the last-named—number two.

Marsden says: "The threads from the bobbin in the creel are conducted down to the trough in which the rollers are arranged; the lower one forming an immersion roller, beneath and around which the threads are conducted, and thence around the upper one to the thread guides and the spindles. Thus the rollers serve the double purpose of immersing the yarn in the water and expressing any superfluous quantity of water it may have taken up."

Nasmith says: "With reference to the drawing rollers, the chief characteristic is that there is only one pair, both being covered with brass, and the upper roller being heavy enough to establish a good nip.

"As the doubling frame, or twister, is not required to draw the twisted yarn, but only to deliver it, all that is necessary is to provide means by which it will be emitted from the rollers at a regular and defined speed. The function of this machine is, therefore, that of twisting only, and no draft need be calculated. Once the relation of the roller delivery and the spindle speed is established for any number of twists, that is all that is required."

In twisting on this machine, the gauge and size of the spindles, the diameter of the ring, the weight of the traveller, and the lift of the bobbin vary according to the number of thread to be twisted.

Close attention should be paid to the following details in this department, *viz.*:—cleanliness, the changing of the water in the troughs, the changing of rings, travellers, and glass rods when showing signs of wear, and last, but most important, slack bands.

Messrs. George Draper & Sons, of Hopedale, Mass., U.S.A., say: "In twisting, as in spinning, the spindle is the chief feature. The Sherman spindle is the best high-speed spindle for this work up to a four-inch ring, where the Sawyer is found more suitable."

By permission of Messrs. Draper, the following tables, taken from their excellent and accurate "Seventh Descriptive Catalogue," are here reproduced:—

DIMENSIONS OF TWISTERS.

Size of ring	1¾ in.	2 in.	2¼ in.	2½ in.	3 in.	3½ in.	4 in.	4½ in.
Space between centres of spindles, or gauge	2¾ in.	3 in.	3¼ in.	3½ in.	4 in.	4½ in.	5 in.	5½ in.
*Total width..........	3 ft. 3½ in.	3 ft. 3¾ in.	3 ft. 4 in.	3 ft. 4¼ in.	3 ft. 4¾ in.	3 ft. 5¼ in.	3 ft. 5¾ in.	3 ft. 6⅜ in.
Approximate weight per spindle in lbs.	21	24	27	30	33	36	39	42
Number of Spindles.	LENGTH OF TWISTERS OVER ALL, IN FEET AND INCHES.							
240	29 6	32 0						
220	27 2½	29 6	31 9½					
200	24 11	27 0	29 1	31 2				
180	22 7½	24 6	26 4½	28 3	32 0			
160	20 4	22 0	23 8	25 4	28 8	32 0		
144	18 6	20 0	21 6	23 0	26 0	29 0	32 0	
140	18 0½	19 6	20 11½	22 5	25 4	28 3	31 2	
128	16 8	18 0	19 4	20 8	23 4	26 0	28 8	31 4
120	15 9	17 0	18 3	19 6	22 0	24 6	27 0	29 6
112	14 10	16 0	17 2	18 4	20 8	23 0	25 4	27 8
108	14 4½	15 6	16 7½	17 9	20 0	22 3	24 6	26 9
100	13 5½	14 6	15 6½	16 7	18 8	20 9	22 10	24 11
96	....	14 0	15 0	16 0	18 0	20 0	22 0	24 0
90	....	....	14 2¼	15 1½	17 0	18 10½	20 9	22 7½
84	....	....	....	14 3	16 0	17 9	19 6	21 3
80	....	....	....	13 8	15 4	17 0	18 8	20 4
70	....	....	....	....	14 0	15 6	17 0	18 6
64	....	....	....	....	....	14 0	15 4	16 8

To ascertain length of Twister, with any number of spindles: Multiply one half the number of spindles by the distance between centres of spindles, add 24, and divide by 12; the quotient and remainder will be the total length in feet and inches.

Diameter of driving pulleys 8 to 14 inches, with 2-inch face. Cylinders are 8 inches in diameter, unless otherwise specified.

*Width of Twister on floor 3 feet 2 inches; the ring rails project beyond other parts, making total width as given above for all sizes at ring rail. he width of head end on level with front roll is 3 feet 7¾ inches.

SPECIFICATION FOR TWISTERS.

Number of dry twisters.
Number of wet twisters.
Number of spindles in each twister.
Twister to be belted (from above or below).
Kind of spindle (Sawyer, Rabbeth, Sherman, etc.)
Diameter of ring.
Kind of ring (vertical or double).
Kind of holder for double ring (cast iron or plate).
Length of traverse.
Wind on (spool, headed bobbin, or filling bobbin).
Number of yarn to be twisted.
Number of ply.
Number turns twist per inch.
Yarn to be twisted from (beams or spools). If spools, send sample marked with name of mill.
Ship (on shoes, in crates, or taken down and boxed).
Ship via——
Blank specification will be sent on application.

In preparing tables of production of our twisters we have assumed the number of the yarn after twisting to be one half for 2-ply, and one fourth for 4-ply, of the number before twisting; the twist is indicated by the number at the head of the table by which the square root of the twisted yarn is multiplied. (See twist tables.) The table covers the most common sizes of ring and numbers of yarn. What we consider to be a fair allowance for loss by all causes from the theoretical production has been made. With this explanation we submit the following table:—

Production of Hopedale Twisters in pounds per spindle per week of sixty hours.

Size of Spindle		No. 3 Sawyer.															
Rev. per minute { spindle		1800		2600				3400				4200					
Rev. per minute { cylinder		582		760				783				711					
Diameter of whirl		2¼ in.		2¼ in.				1¼ in.				1¼ in.					
Gauge		5½ in.		5 in.				4½ in.				4 in.					
Diameter of ring		4½ in.		4 in.				3½ in.				3 in.					
Diameter of bobbin {		Head, 4½ in. Barl. 1¾ in.		Head, 3¾ in. Barrel. 1⅝ in.				Head, 3½ in. Barrel, 1¼ in.				Head, 2¾ in. Barrel, 1¼ in.					
Length of traverse		6 in.		6 in.				6 in.				5½ in.					
Weight of yarn on bobbin		1·197 lbs.		·873 lbs.				·74 lbs.				·46 lbs.					
Number of ply		6		4		6		3		4		2		3		4	
Twist=sq. rt. of number of twisted yarn ×		4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5
Number of yarn to be twisted.	6	46·10	37·28	36·10	29·21	....	....	30·92	25·03	....	....	20·87	16·91				
	7	36·99	29·85	28·98	23·40	....	....	24·83	20·05	....	....	16·78	13·57				
	8	30·51	24·58	23·93	19·29	....	....	20·50	16·53	30·92	25·03	13·86	11·18				
	9	25·72	20·70	20·17	16·24	....	....	17·29	13·92	26·16	21·13	11·70	9·42	20·87	16·91		
	10	22·06	17·73	17·31	13·92	31·08	25·11	14·83	11·93	22·49	18·15	10·04	8·08	17·99	14·55		
	11	19·18	15·41	15·06	12·10	27·12	21·88	12·90	10·37	19·61	15·80	8·73	7·02	15·70	12·68		
	12	16·88	13·56	13·25	10·65	23·93	19·29	11·36	9·12	17·29	13·92	7·69	6·18	13·86	11·18	20·87	16·91
	13	....	....	....	....	21·31	17·16	....	....	15·39	12·38	....	....	12·35	9·96	18·64	15·08
	14	....	....	....	....	19·14	15·40	....	....	13·81	11·10	....	....	11·10	8·94	16·78	13·56
	15	....	....	....	....	17·31	13·92	....	....	12·48	10·03	....	....	10·04	8·08	15·21	12·28
	16	....	....	....	....	15·75	12·66	....	....	11·36	9·12	....	....	9·14	7·35	13·86	11·18
	17	....	....	....	....	14·41	11·58	....	....	....	....	....	....	8·36	6·72	12·70	10·24
	18	....	....	....	....	13·25	10·65	....	....	....	....	....	....	7·69	6·18	11·70	9·42
	19	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10·82	8·71
	20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10·04	8·08
	21	....	....	....	....	....	....	....	....	....	....	....	....	....	....	9·35	7·52
	22	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8·74	7·03
	23	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8·19	6·58
	24	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7·69	6·18

TWISTER TABLES.

Production of Hopedale Twisters in pounds per spindle per week of sixty hours.—*Continued.*

Size of Spindle								No. 27 Sherman					
Rev per minute { spindle. cylinder		5000 769						5500 846				6000 831	
Diameter of whirl		1¼ in.						1⅛ in.				1 in.	
Gauge		3½ in.						3¼ in.				3 in.	
Diameter of ring		2½ in.						2¼ in.				2 in.	
Diameter of bobbin		Head, 2¼ in. Barrel, ⅞ in.						Head, 2 in. Barrel, ⅞ in				{ Head, 1¾ in Barrel ¾ in.	
Length of Traverse		5½ in.						5½ in.				5 in.	
Weight of yarn on bobbin		·334 lbs.						·255 lbs.				·182 lbs.	
Number of ply		2		3		4		2		3		2	
Twist=sq. rt. of number of twisted yarn ×		4	5	4	5	4	5	5	6	5	6	5	6
Number of yarn to be twisted.	8	16·21	13·15										
	9	13·74	11·12										
	10	11 83	9·56										
	11	10·32	8·33										
	12	9·10	7·34	16·21	13·15	....	....	8·04	6·75				
	13	8·11	6·53	14·49	11·73	....	....	7·16	6·01				
	14	7·28	5·86	13·05	10·55	....	....	6·44	5·40				
	15	6·59	5·30	11·83	9·56	....	....	5·82	4·88				
	16	5·99	4·82	10·78	8·71	16·21	13·15	5·30	4·44				
	17	....	....	9·89	7·97	14·89	12·06	4·85	4·06				
	18	....	....	9·10	7·54	13·74	11·12	4·46	3·74	8·04	6·75		
	19	.. .	....	8·42	6·78	12·72	10·28	4·12	3·45	7·44	6·24		
	20	....	....	7·82	6·29	11·83	9·56	3·83	3·20	6·91	5·79	4·17	3·49
	21	....	....	7·28	5·86	11·03	8·91	3·56	2·98	6·44	5·40	3·88	3·25
	22	....	....	6·81	5·47	10·32	8·33	3·32	2·78	6·02	5·04	3·63	3·04
	23	....	....	6·38	5·13	9·68	7·81	3·11	2·60	5·64	3·72	3·40	2·84
	24	....	....	5·99	4·82	9·10	7·34	2·93	2·44	5·30	4·44	3·19	2·67

Size of Spindle				No. 27 Sherman.											
Rev. per minute { spindle.. cylinder		5000 769		5500 846				6000 831				6800 837			
Diameter of whirl		1¼ in.		1⅛ in.				1 in.				⅞ in.			
Gauge		3½ in.		3¼ in.				3 in.				2¾ in.			
Diameter of ring		2½ in.		2¼ in.				2 in.				1¾ in.			
Diameter of bobbin {		Head, 2¼ in. Barrel, ⅞ in.		Head, 2 in. Barrel, ⅞ in.				Head, 1¾ in. Barrel, ¾ in.				Head, 1½ in. Barrel, ⅝ in.			
Length of traverse		5½ in.		5½ in.				5 in.				5 in.			
Weight of yarn on bobbin		·334 lbs		·255 lbs.				·182 lbs.				·125 lbs.			
Number of ply		4		2		3		2		3		2		3	
Twist=sq. rt. of number of twisted yarn ×		4	5	5	6	5	6	5	6	5	6	5	6	5	6
Number of yarn to be twisted.	25	8·58	6·92	2·75	2·30	5·00	4·18	3·01	2·52						
	26	8·11	6·53	2·60	2·17	4·72	3·95	2·84	2·37						
	27	7·68	6·18	2·46	2·05	4·46	3·74	2·69	2·25						
	28	7·28	5·86	2·33	1·94	4·23	3·54	2·55	2·13						
	29	6·92	5.57	....	....	4·02	3·36	2·42	2·02						
	30	6·59	5·30	....	....	3·83	3·20	2·30	1·92	4·17	3·49				
	32	5·99	4·82	....	....	3·48	2·91	2·09	1·75	3·79	3·18				
	34	....	....	....	....	3·18	2·66	1·91	1·60	3·47	2·91				
	36	....	....	....	....	2·93	2·44	1·76	1·47	3·19	2·67				
	38	....	....	....	....	2·70	2·26	1·62	1·35	2·95	2·47				
	40	....	....	....	....	2·50	2·09	1·50	1·26	2·74	2·29	1·69	1·41		
	42	....	....	....	....	2·33	1 94	1·40	1·17	2·55	2·13	1·57	1·32		
	44	....	....	....	....	....	....	1·31	1·09	2·38	1·99	1·47	1·23		
	46	....	....	....	....	....	....	1·22	1·02	2·23	1·86	1·38	1·15		
	48	....	....	....	....	....	....	1·15	·96	2·09	1·75	1·29	1·08		
	50	....	....	....	....	....	....	1·08	·90	1·97	1·65	1·22	1·02	2·21	1·85
	60	....	....	....	....	....	....	....	....	1·50	1·26	·93	·78	1·69	1·41
	70	....	....	....	....	....	....	....	....	....	....	·74	·62	1·35	1·13
	80	....	....	....	....	....	....	....	....	....	....	·61	·51	1·11	·92

TWIST TABLES FOR TWISTED YARNS.

TWO PLY.

No. of yarn to be twstd	No. of twisted yarn.	Sq root of No. twisted yarn	Square root multiplied by			No. of yarn to be twstd	No. of twisted yarn.	Sq. root of No. twisted yarn	Square root multiplied by	
			4	5	6				5	6
1	·5	·7071	2·83	3·54	4·24	76	38·	6·1644	30·82	36·99
2	1·	1·	4·	5·	6·	77	38·5	6·2049	31·02	37·23
3	1·5	1·2247	4·90	6·12	7·35	78	39·	6·2450	31·22	37·47
4	2·	1·4142	5·66	7·07	8·49	79	39·5	6·2849	31·42	37·71
5	2·5	1·5811	6·32	7·91	9·49	80	40·	6·3246	31·62	37·95
6	3·	1·7321	6·93	8·66	10·39	81	40·5	6·3640	31·82	38·18
7	3·5	1·8708	7·48	9·35	11·22	82	41·	6·4031	32·02	38·42
8	4·	2·	8·	10·	12·	83	41·5	6·4420	32·21	38·65
9	4·5	2·1213	8·49	10·61	12·73	84	42·	6·4807	32·40	38·88
10	5·	2·2361	8·94	11·18	13·42	85	42·5	6·5192	32·60	39·12
11	5·5	2·3452	9·38	11·73	14·07	86	43·	6·5574	32·79	39·34
12	6·	2·4495	9·80	12·25	14·70	87	43·5	6·5955	32·98	39·57
13	6·5	2·5495	10·20	12·75	15·30	88	44·	6·6332	33·17	39·80
14	7·	2·6458	10·58	13·23	15·87	89	44·5	6·6708	33·35	40·02
15	7·5	2·7386	10·95	13·69	16·43	90	45·	6·7082	33·54	40·25
16	8·	2·8284	11·31	14·14	16·97	91	45·5	6·7454	33·73	40·47
17	8·5	2·9155	11·66	14·58	17·49	92	46·	6·7823	33·91	40·69
18	9·	3·	12·	15·	18·	93	46·5	6·8191	34·10	40·91
19	9·5	3·0822	12·33	15·41	18·49	94	47·	6·8557	34·28	41·13
20	10·	3·1623	12·65	15·81	18·97	95	47·5	6·8920	34·46	41·35
21	10·5	3·2404	12·96	16·20	19·44	96	48·	6·9282	34·64	41·57
22	11·	3·3166	13·27	16·58	19·90	97	48·5	6·9642	34·82	41·79
23	11·5	3·3912	13·56	16·96	20·35	98	49·	7·	35·	42·
24	12·	3·4641	13·86	17·32	20·78	99	49·5	7·0356	35·18	42·21
25	12·5	3·5355	14·14	17·68	21·21	100	50·	7·0711	35·36	42·43
26	13·	3·6056	14·42	18·03	21·63	101	50·5	7·1063	35·53	42·64
27	13·5	3·6742	14·70	18·37	22·05	102	51·	7·1414	35·70	42·85
28	14·	3·7417	14·97	18·71	22·45	103	51·5	7·1763	35·88	43·06
29	14·5	3·8079	15·23	19·04	22·85	104	52·	7·2111	36·06	43·27
30	15·	3·8730	15·49	19·37	23·24	105	52·5	7·2457	36·23	43·47
31	15·5	3·9370	15·75	19·69	23·62	106	53·	7·2801	36·40	43·68
32	16·	4·	16·	20·	24·	107	53·5	7·3144	36·57	43·89
33	16·5	4·0620	16·25	20·31	24·37	108	54·	7·3485	36·74	44·09
34	17·	4·1231	16·49	20·62	24·74	109	54·5	7·3824	36·91	44·29
35	17·5	4·1833	16·73	20·92	25·10	110	55·	7·4162	37·08	44·50
36	18·	4·2426	16·97	21·21	25·46	111	55·5	7·4498	37·25	44·70
37	18·5	4·3012	17·20	21·51	25·81	112	56·	7·4833	37·42	44·90
38	19·	4·3589	17·44	21·79	26·15	113	56·5	7·5166	37·58	45·10
39	19·5	4·4159	17·66	22·08	26·50	114	57·	7·5498	37·75	45·30
40	20·	4·4721	17·89	22·36	26·83	115	57·5	7·5829	37·91	45·50
41	20·5	4·5277	18·11	22·64	27·17	116	58·	7·6158	38·08	45·69
42	21·	4·5826	18·33	22·91	27·50	117	58·5	7·6485	38·24	45·89
43	21·5	4·6368	18·55	23·18	27·82	118	59·	7·6811	38·41	46·09
44	22·	4·6904	18·76	23·45	28·14	119	59·5	7·7136	38·57	46·28
45	22·5	4·7434	18·97	23·72	28·46	120	60·	7·7460	38·73	46·48
46	23·	4·7958	19·18	23·98	28·77	121	60·5	7·7782	38·89	46·67
47	23·5	4·8477	19·39	24·24	29·09	122	61·	7·8102	39·05	46·86
48	24·	4·8990	19·60	24·49	29·39	123	61·5	7·8422	39·21	47·05
49	24·5	4·9497	19·80	24·75	29·70	124	62·	7·8740	39·37	47·24
50	25·	5·	20·	25·	30·	125	62·5	7·9057	39·53	47·43
51	25·5	5·0498	20·20	25·25	30·30	126	63·	7·9373	39·69	47·62
52	26·	5·0990	20·40	25·50	30·59	127	63·5	7·9687	39·84	47·81
53	26·5	5·1478	20·59	25·74	30·89	128	64·	8·	40·	48·
54	27·	5·1962	20·78	25·98	31·18	129	64·5	8·0312	40·16	48·19
55	27·5	5·2440	20·98	26·22	31·46	130	65·	8·0623	40·31	48·37
56	28·	5·2915	21·17	26·46	31·75	131	65·5	8·0932	40·47	48·56
57	28·5	5·3385	21·35	26·69	32·03	132	66·	8·1240	40·62	48·74
58	29·	5·3852	21·54	26·93	32·31	133	66·5	8·1548	40·77	48·93
59	29·5	5·4314	21·73	27·16	32·59	134	67·	8·1854	40·93	49·11
60	30·	5·4772	21·91	27·39	32·86	135	67·5	8·2158	41·08	49·30
61	30·5	5·5227	22·09	27·61	33·14	136	68·	8·2462	41·23	49·48
62	31·	5·5678	22·27	27·84	33·41	137	68·5	8·2765	41·38	49·66
63	31·5	5·6125	22·45	28·06	33·67	138	69·	8·3066	41·53	49·84
64	32·	5·6569	22·63	28·28	33·94	139	69·5	8·3367	41·68	50·02
65	32·5	5·7009	22·80	28·50	34·21	140	70·	8·3666	41·83	50·20
66	33·	5·7446	22·98	28·72	34·47	141	70·5	8·3964	41·98	50·38
67	33·5	5·7879	23·15	28·94	34·73	142	71·	8·4261	42·13	50·56
68	34·	5·8310	23·32	29·15	34·99	143	71·5	8·4558	42·28	50·73
69	34·5	5·8737	23·49	29·37	35·24	144	72·	8·4853	42·43	50·91
70	35·	5·9161	23·66	29·58	35·50	145	72·5	8·5147	42·57	51·09
71	35·5	5·9582	23·83	29·79	35·75	146	73·	8·5440	42·72	51·26
72	36·	6·	24·	30·	36·	147	73·5	8·5732	42·87	51·44
73	36·5	6·0415	24·17	30·21	36·25	148	74·	8·6023	43·01	51·61
74	37·	6·0828	24·33	30·41	36·50	149	74·5	8·6313	43·16	51·79
75	37·5	6·1237	24·49	30·62	36·74	150	75·	8·6603	43·30	51·96

TWIST TABLES FOR TWISTED YARNS.

THREE PLY.

No. of yarn to be twstd	No. of twisted yarn.	Sq root of No. twisted yarn.	Square root multiplied by			No of yarn to be twstd	No. of twisted yarn.	Sq. root of No. twisted yarn	Square root multiplied by	
			4	5	6				5	6
1	·33	·5774	2·31	2·89	3·46	76	25·33	5·0332	25·17	30·20
2	·67	·8165	3·27	4·08	4·90	77	25·67	5·0662	25·33	30·40
3	1·	1·	4·	5·	6·	78	26·	5·0990	25·50	30·59
4	1·33	1·1547	4·62	5·77	6·93	79	26·33	5·1316	25·66	30·79
5	1·67	1·2910	5·16	6·45	7·95	80	27·67	5·1640	25·82	30·98
6	2·	1·4142	5·66	7·07	8·49	81	27·	5·1962	25·98	31·18
7	2·33	1·5275	6·11	7·64	9·17	82	27·33	5·2281	26·14	31·37
8	2·67	1·6330	6·53	8·16	9·80	83	27·67	5·2599	26·30	31·56
9	3·	1·7321	6·93	8·66	10·39	84	28·	5·2915	26·46	31·75
10	3·33	1·8257	7·30	9·13	10·95	85	28·33	5·3229	26·61	31·94
11	3·67	1·9149	7·66	9·57	11·49	86	28·67	5·3541	26·77	32·12
12	4·	2·	8·	10·	12·	87	29·	5·3852	26·93	32·81
13	4·33	2·0817	8·33	10·41	12·49	88	29·33	5·4160	27·08	32·50
14	4·67	2·1602	8·64	10·80	12·96	89	29·67	5·4467	27·23	32·68
15	5·	2·2361	8·94	11·18	13·42	90	30·	5·4772	27·39	32·86
16	5·33	2·3094	9·24	11·55	13·86	91	30·33	5·5076	27·54	33·05
17	5·67	2·3805	9·52	11·90	14·28	92	30·67	5·5377	27·69	33·23
18	6·	2·4495	9·80	12·25	14·70	93	31·	5·5678	27·84	33·41
19	6·33	2·5166	10·07	12·58	15·10	94	31·33	5·5976	27·99	33·59
20	6·67	2·5820	10·33	12·91	15·49	95	31·67	5·6273	28·14	33·76
21	7·	2·6458	10·58	13·23	15·87	96	32·	5·6569	28·28	33·94
22	7·33	2·7080	10·83	13·54	16·25	97	32·33	5·6862	28·43	34·12
23	7·67	2·7089	11·08	13·84	16·61	98	32·67	5·7155	28·58	34·29
24	8·	2·8284	11·31	14·14	16·97	99	33·	5·7446	28·72	34·47
25	8·33	2·8868	11·55	14·43	17·32	100	33·33	5·7735	28·87	34·64
26	8·67	2·9439	11·76	14·72	17·66	101	33·67	5·8023	29·01	34·81
27	9·	3·	12·	15·	18·	102	34·	5·8310	29·15	34·99
28	9·33	3·0551	12·22	15·28	18·33	103	34·33	5·8595	29·30	35·16
29	9·67	3·1091	12·44	15·55	18·65	104	34·67	5·8878	29·44	35·33
30	10·	3·1623	12·65	15·81	18·97	105	35·	5·9161	29·58	35·40
31	10·33	3·2145	12·86	16·07	19·29	106	35·33	5·9442	29·72	35·67
32	10·67	3·2659	13·06	16·33	19·60	107	35·67	5·9722	29·86	35·83
33	11·	3·3166	13·27	16·58	19·90	108	36·	6·	30·	36·
34	11·33	3·3665	13·47	16·83	20·20	109	36·33	6·0277	30·14	36·17
35	11·67	3·4157	13·66	17·08	20·49	110	36·67	6·0553	30·28	36·33
36	12·	3·4641	13·86	17·32	20·78	111	37·	6·0828	30·41	36·50
37	12·33	3·5119	14·05	17·56	21·07	112	37·33	6·1101	30·55	36·66
38	12·67	3·5590	14·24	17·80	21·35	113	37·67	6·1374	30·69	36·83
39	13·	3·6056	14·42	18·03	21·63	114	38·	6·1644	30·82	36·99
40	13·33	3·6515	14·61	18·26	21·91	115	38·33	6·1914	30·96	37·15
41	13·67	3·6969	14·79	18·48	22·18	116	38·67	6·2183	31·09	37·31
42	14·	3·7417	14·97	18·71	22·45	117	39·	6·2450	31·22	37·47
43	14·33	3·7859	15·14	18·93	22·72	118	39·33	6·2716	31·36	37·63
44	14·67	3·8297	15·38	19·15	22·98	119	39·67	6·2981	31·49	37·79
45	15·	3·8730	15·49	19·36	23·24	120	40·	6·3246	31·62	37·95
46	15·33	3·9158	15·66	19·58	23·49	121	40·33	6·3509	31·75	38·11
47	15·67	3·9582	15·83	19·79	23·75	122	40·67	6·3770	31·89	38·26
48	16·	4·	16·	20·	24·	123	41·	6·4031	32·02	38·42
49	16·33	4·0415	16·17	20·21	24·25	124	41·33	6·4291	32·15	38·57
50	16·67	4·0825	16·33	20·41	24·49	125	41·67	6·4550	32·27	38·73
51	17·	4·1231	16·49	20·62	24·74	126	42·	6·4807	32·40	38·88
52	17·33	4·1633	16·65	20·82	24·98	127	42·33	6·5064	32·53	39·04
53	17·67	4·2032	16·81	21·02	25·22	128	42·67	6·5320	32·66	39·19
54	18·	4·2426	16·97	21·21	25·46	129	43·	6·5574	32·79	39·34
55	18·33	4·2817	17·13	21·41	25·69	130	43·33	6·5828	32·91	39·50
56	18·67	4·3205	17·28	21·60	25·92	131	43·67	6·6081	33·04	39·65
57	19·	4·3589	17·44	21·79	26·15	132	44·	6·6332	33·17	39·80
58	19·33	4·3970	17·59	21·98	26·38	133	44.33	6·6583	33·29	39·95
59	19·67	4·4347	17·74	22·17	26·61	134	44·67	6·6833	33·42	40·10
60	20·	4·4721	17·89	22·36	26·83	135	45·	6·7082	33·54	40·25
61	20·33	4·5092	18·04	22·55	27·06	136	45·33	6·7330	33·67	40·40
62	20·67	4·5461	18·18	22·73	27·28	137	45·67	6·7577	33·79	40·55
63	21·	4·5826	18·33	22·91	27·50	138	46·	6·7823	33·91	40·69
64	21·33	4·6188	18·48	23·09	27·71	139	46·33	6·8069	34·04	40·84
65	21·67	4·6547	18·62	23·27	27·93	140	46·67	6·8313	34·16	40·99
66	22·	4·6904	18·76	23·45	28·14	141	47·	6·8557	34·28	41·13
67	22·33	4·7258	18·90	23·63	28·35	142	47·33	6·8799	34·40	41·28
68	22·67	4·7610	19·04	23·80	28·57	143	47·67	6·9041	34·52	41·42
69	23·	4·7958	19·18	23·98	28·77	144	48·	6·9282	34·64	41·57
70	23·33	4·8305	19·32	24·15	28·98	145	48·33	6·9522	34·76	41·71
71	23·67	4·8648	19·46	24·32	29·19	146	48·67	6·9762	34·88	41·86
72	24·	4·8990	19·60	24·49	29·39	147	49·	7·	35·	42·
73	24·33	4·9329	19·73	24·66	29·60	148	49·33	7·0238	35·12	42·14
74	24·67	4·9666	19·87	24·83	29·80	149	49·67	7·0475	35·24	42·28
75	25·	5·	20·	25·	30·	150	50·	7·0711	35·36	42·43

TWIST TABLES FOR TWISTED YARNS.

FOUR PLY.

No. of yarn to be twstd	No. of twisted yarn.	Sq root of No. twisted yarn.	Square root multiplied by			No. of yarn to be twstd	No. of twisted yarn.	Sq. root of No. twisted yarn	Square root multiplied by	
			4	5	6				5	6
1	·25	·5	2·	2·5	3	76	19·	4·3589	21·79	26·15
2	·50	·7071	2·83	3·54	4·24	77	·25	4·3875	21·94	26·32
3	·75	·8660	3·46	4·33	5·20	78	·50	4·4159	22·08	26·50
4	1·	1·	4·	5·	6·	79	·75	4·4441	22·22	26·66
5	·25	1·1180	4·47	5·59	6·71	80	20·	4·4721	22·36	26·83
6	·50	1·2247	4·90	6·12	7·35	81	·25	4·5	22·5	27·
7	·75	1·3229	5·29	6·61	7·94	82	·50	4·5277	22·64	27·17
8	2·	1·4142	5·66	7·07	8·49	83	·75	4·5552	22·78	27·33
9	·25	1·5	6·	7·5	9·	84	21·	4·5826	22·91	27·50
10	·50	1·5811	6·32	7·91	9·49	85	·25	4·6098	23·05	27·66
11	·75	1·6583	6·63	8·29	9·95	86	·50	4·6368	23·18	27·82
12	3·	1·7321	6·93	8·66	10·39	87	·75	4·6637	23·32	27·98
13	·25	1·8028	7·21	9·01	10·82	88	22·	4·6904	23·45	28·14
14	·50	1·8708	7·48	9·35	11·22	89	·25	4·7170	23·58	28·30
15	·75	1·9365	7·75	9·68	11·62	90	·50	4·7434	23·72	28·46
16	4·	2·	8·	10·	12·	91	·75	4·7697	23·85	28·62
17	·25	2·0616	8·25	10·31	12·37	92	23·	4·7958	23·98	28·77
18	·50	2·1213	8·49	10·61	12·73	93	·25	4·8218	24·11	28·93
19	·75	2·1794	8·72	10·90	13·08	94	·50	4·8477	24·24	29·09
20	5·	2·2361	8·94	11·18	13·42	95	·75	4·8734	24·37	29·24
21	·25	2·2913	9·17	11·49	13·75	96	24·	4·8990	24·49	29·39
22	·50	2·3452	9·38	11·73	14·07	97	·25	4·9244	24·62	29·55
23	·75	2·3979	9·59	11·99	14·39	98	·50	4·9497	24·75	29·70
24	6·	2·4495	9·80	12·25	14·70	99	·75	4·9749	24·87	29·85
25	·25	2·5	10·	12·5	15·	100	25·	5·	25·	30·
26	·50	2·5495	10·20	12·75	15·30	101	·25	5·0249	25·12	30·15
27	·75	2·5981	10·39	12·99	15·59	102	·50	5·0498	25·25	30·30
28	7·	2·6458	10·58	13·23	15·87	103	·75	5·0744	25·37	30·45
29	·25	2·6926	10·77	13·46	16·16	104	26·	5·0990	25·50	30·59
30	·50	2·7386	10·95	13·69	16·43	105	·25	5·1235	25·62	30·74
31	·75	2·7839	11·14	13·92	16·70	106	·50	5·1478	25·74	30·89
32	8·	2·8284	11·31	14·14	16·97	107	·75	5·1720	25·86	31·03
33	·25	2·8723	11·49	14·36	17·23	108	27·	5·1962	25·98	31·18
34	·50	2·9155	11·66	14·58	17·49	109	·25	5·2202	26·10	31·32
35	·75	2·9580	11·83	14·79	17·75	110	·50	5·2440	26·22	31·46
36	9·	3·	12·	15·	18·	111	·75	5·2678	26·34	31·61
37	·25	3·0414	12·17	15·21	18·25	112	28·	5·2915	26·46	31·75
38	·50	3·0822	12·33	15·41	18·49	113	·25	5·3151	26·58	31·89
39	·75	3·1225	12·49	15·61	18·73	114	·50	5·3385	26·69	32·03
40	10·	3·1623	12·65	15·81	18·97	115	·75	5·3619	26·81	32·17
41	·25	3·2016	12·81	16·01	19·21	116	29·	5·3852	26·93	32·31
42	·50	3·2404	12·96	16·20	19·44	117	·25	5·4083	27·04	32·45
43	·75	3·2787	13·11	16·39	19·67	118	·50	5·4314	27·16	32·59
44	11·	3·3166	13·27	16·58	19·90	119	·75	5·4543	27·27	32·73
45	·25	3·3541	13·42	16·77	20·12	120	30·	5·4772	27·39	32·86
46	·50	3·3912	13·56	16·96	20·35	121	·25	5·5	27·5	33·
47	·75	3·4278	13·71	17·14	20·57	122	·50	5·5227	27·61	33·14
48	12·	3·4641	13·86	17·32	20·78	123	·75	5·5453	27·73	33·27
49	·25	3·5	14·	17·5	21·	124	31·	5·5678	27·84	33·41
50	·50	3·5355	14·14	17·68	21·21	125	·25	5·5902	27·95	33·54
51	·75	3·5707	14·28	17·85	21·42	126	·50	5·6125	28·06	33·67
52	13·	3·6056	14·42	18·03	21·63	127	·75	5·6347	28·17	33·81
53	·25	3·6401	14·56	18·20	21·84	128	32·	5·6569	28·28	33·94
54	·50	3·6742	14·70	18·37	22·05	129	·25	5·6789	28·39	34·07
55	·75	3·7081	14·83	18·54	22·25	130	·50	5·7009	28·50	34·21
56	14·	3·7417	14·97	18·71	22·45	131	·75	5·7228	28·61	34·34
57	·25	3·7749	15·10	18·87	22·65	132	33·	5·7446	28·72	34·47
58	·50	3·8079	15·23	19·04	22·85	133	·25	5·7663	28·83	34·60
59	·75	3·8406	15·36	19·20	23·04	134	·50	5·7879	28·94	34·73
60	15·	3·8730	15·49	19·37	23·24	135	·75	5·8095	29·05	34·86
61	·25	3·9051	15·62	19·53	23·43	136	34·	5·8310	29·15	34·99
62	·50	3·9370	15·75	19·69	23·62	137	·25	5·8524	29·26	35·11
63	·75	3·9686	15·88	19·84	23·81	138	·50	5·8737	29·37	35·24
64	16·	4·	16·	20·	24·	139	·75	5·8949	29·47	35·37
65	·25	4·0311	16·12	20·16	24·19	140	35·	5·9161	29·58	35·50
66	·50	4·0620	16·25	20·31	24·37	141	·25	5·9372	29·69	35·62
67	·75	4·0927	16·37	20·46	24·56	142	·50	5·9582	29·79	35·75
68	17·	4·1231	16·49	20·62	24·74	143	·75	5·9791	29·90	35·87
69	·25	4·1533	16·61	20·77	24·92	144	36·	6·	30·	36·
70	·50	4·1833	16·73	20·92	25·10	145	·25	6·0208	30·10	36·12
71	·75	4·2130	16·85	21·07	25·28	146	·50	6·0415	30·21	36·25
72	18·	4·2426	16·97	21·21	25·46	147	·75	6·0622	30·31	36·37
73	·25	4·2720	17·09	21·36	25·63	148	37·	6·0828	30·41	36·50
74	·50	4·3012	17·20	21·51	25·81	149	·25	6·1033	30·52	36·62
75	·75	4·3301	17·32	21·65	25·98	150	·50	6·1237	30·62	36·74

TWIST TABLES FOR TWISTED YARNS.

FIVE PLY.

No. of yarn to be twstd	No. of twisted yarn.	Sq root of No. twisted yarn	Square root multiplied by			No. of yarn to be twstd	No. of twisted yarn.	Sq. root of No. twisted yarn	Square root multiplied by	
			4	5	6				5	6
1	·2	·4472	1·79	2·24	2·68	76	15·2	3·8987	19·49	23·39
2	·4	·6325	2·53	3·16	3·79	77	·4	3·9243	19·62	23·55
3	·6	·7746	3·10	3·87	4·65	78	·6	3·9497	19·75	23·70
4	·8	·8944	3·58	4·47	5·37	79	·8	3·9749	19·87	23·85
5	1·	1·	4·	5·	6·	80	16·	4·	20·	24·
6	·2	1·0954	4·38	5·48	6·57	81	·2	4·0249	20·12	24·15
7	·4	1·1832	4·73	5·92	7·10	82	·4	4·0497	20·25	24·30
8	·6	1·2649	5·06	6·32	7·59	83	·6	4·0743	20·37	24·45
9	·8	1·3416	5·37	6·71	8·05	84	·8	4·0988	20·49	24·59
10	2·	1·4142	5·66	7·07	8·49	85	17·	4·1231	20·62	24·74
11	·2	1·4832	5·93	7·42	8·90	86	·2	4·1473	20·74	24·88
12	·4	1·5492	6·20	7·75	9·30	87	·4	4·1713	20·86	25·03
13	·6	1·6125	6·45	8·06	9·67	88	·6	4·1952	20·98	25·17
14	·8	1·6733	6·69	8·37	10·04	89	·8	4·2190	21·10	25·31
15	3·	1·7321	6·93	8·66	10·39	90	18·	4·2426	21·21	25·46
16	·2	1·7889	7·16	8·95	10·73	91	·2	4·2661	21·33	25·60
17	·4	1·8439	7·38	9·22	11·06	92	·4	4·2895	21·45	25·74
18	·6	1·8974	7·59	9·49	11·38	93	·6	4·3128	21·56	25·88
19	·8	1·9494	7·80	9·75	11·70	94	·8	4·3359	21·68	26·02
20	4·	2·	8·	10·	12·	95	19·	4·3589	21·79	26·15
21	·2	2·0494	8·20	10·25	12·30	96	·2	4·3818	21·91	26·29
22	·4	2·0976	8·39	10·49	12·59	97	·4	4·4045	22·02	26·43
23	·6	2·1448	8·58	10·72	12·87	98	·6	4·4272	22·14	26·56
24	·8	2·1909	8·76	10·95	13·15	99	·8	4·4497	22·25	26·70
25	5·	2·2361	8·94	11·18	13·42	100	20·	4·4721	22·36	26·83
26	·2	2·2804	9·12	11·40	13·68	101	·2	4·4944	22·47	26.97
27	·4	2·3238	9·30	11·62	13·94	102	·4	4·5166	22·58	27·10
28	·6	2·3664	9·47	11·83	14·20	103	·6	4·5387	22·69	27·23
29	·8	2·4083	9·63	12·04	14·45	104	·8	4·5607	22·80	27·36
30	6·	2·4495	9·80	12·25	14·70	105	21·	4·5826	22·91	27·50
31	·2	2·4900	9·96	12·45	14·94	106	·2	4·6043	23·02	27·63
32	·4	2·5298	10·12	12·65	15·18	107	·4	4·6260	23·13	27·76
33	·6	2·5690	10·28	12·85	15·41	108	·6	4·6476	23·24	27·89
34	·8	2·6077	10·43	13·04	15·65	109	·8	4·6690	23·35	28·01
35	7·	2·6458	10·58	13·23	15·87	110	22·	4·6904	23·45	28·14
36	·2	2·6833	10·73	13·42	16·10	111	·2	4·7117	23·56	28·27
37	·4	2·7203	10·88	13·60	16·32	112	·4	4·7329	23·66	28·40
38	·6	2·7568	11·03	13·78	16·54	113	·6	4·7539	23·77	28·52
39	·8	2·7928	11·17	13·96	16·76	114	·8	4·7749	23·87	28·65
40	8·	2·8284	11·31	14·14	16·97	115	23·	4·7958	23·98	28·77
41	·2	2·8636	11·45	14·32	17·18	116	·2	4·8166	24·08	28·90
42	·4	2·8983	11·59	14·49	17·39	117	·4	4·8374	24·19	29·02
43	·6	2·9326	11·73	14·66	17·60	118	·6	4·8580	24·29	29·15
44	·8	2·9665	11·87	14·83	17·80	119	·8	4·8785	24·39	29·27
45	9·	3·	12·	15·	18·	120	24·	4·8990	24·49	29·39
46	·2	3·0332	12·13	15·17	18·20	121	·2	4·9193	24·60	29·52
47	·4	3·0659	12·26	15·33	18·40	122	·4	4·9396	24·70	29·64
48	·6	3·0984	12·39	15·49	18·59	123	·6	4·9598	24·80	29·76
49	·8	3·1305	12·52	15·65	18·78	124	·8	4·9800	24·90	29·88
50	10·	3·1623	12·65	15·81	18·97	125	25·	5·	25·	30·
51	·2	3·1937	12·77	15·97	19·16	126	·2	5·0200	25·10	30·12
52	·4	3·2249	12·90	16·12	19·35	127	·4	5·0398	25·20	30·24
53	·6	3·2558	13·02	16·28	19·53	128	·6	5·0596	25·30	30·36
54	·8	3·2863	13·15	16·43	19·72	129	·8	5·0794	25·40	30·48
55	11·	3·3166	13·27	16·58	19·90	130	26·	5·0990	25·50	30·59
56	·2	3·3466	13·39	16·73	20·08	131	·2	5·1186	25·59	30·71
57	·4	3·3764	13·51	16·88	20·26	132	·4	5·1381	25·69	30·83
58	·6	3·4059	13·62	17·03	20·44	133	·6	5·1575	25·79	30·95
59	·8	3·4351	13·74	17·18	20·61	134	·8	5·1769	25·88	31·06
60	12·	3·4641	13·86	17·32	20·78	135	27·	5·1962	25·98	31·18
61	·2	3·4928	13·97	17·46	20·96	136	·2	5·2154	26·08	31·29
62	·4	3·5214	14·09	17·61	21·13	137	·4	5·2345	26·17	31·41
63	·6	3·5496	14·20	17·75	21·30	138	·6	5·2536	26·27	31·52
64	·8	3·5777	14·31	17·89	21·47	139	·8	5·2726	26·36	31·64
65	13·	3·6056	14·42	18·03	21·63	140	28·	5·2915	26·46	31·75
66	·2	3·6332	14·53	18·17	21·80	141	·2	5·3104	26·55	31·86
67	·4	3·6606	14·64	18·30	21·96	142	·4	5·3292	26·65	31·97
68	·6	3·6878	14·75	18·44	22·13	143	·6	5·3479	26·74	32·09
69	·8	3·7148	14·86	18·57	22·29	144	·8	5·3666	26·83	32·20
70	14·	3·7417	14·97	18·71	22·45	145	29·	5·3852	26·93	32·31
71	·2	3·7683	15·07	18·84	22·61	146	·2	5·4037	27·02	32·42
72	·4	3·7947	15·18	18·97	22·77	147	·4	5·4222	27·11	32·53
73	·6	3·8210	15·28	19·10	22·93	148	·6	5·4406	27·20	32·64
74	·8	3·8471	15·38	19·24	23·08	149	·8	5·4589	27·29	32·75
75	15·	3·8730	15·49	19·37	23·24	150	30·	5·4772	27·39	32·86

TWIST TABLES FOR TWISTED YARNS.

SIX PLY.

No. of yarn to be twstd	No. of twisted yarn.	Sq root of No. twisted yarn	Square root multiplied by		
			4	5	6
1	·17	·4082	1·63	2·04	2·45
2	·33	·5774	2·31	2·89	3·46
3	·50	·7071	2·83	3·54	4·24
4	·67	·8165	3·27	4·08	4·90
5	·83	·9129	3·65	4·56	5·48
6	1·	1·	4·	5·	6·
7	·17	1·0801	4·32	5·40	6·48
8	·33	1·1547	4·62	5·77	6·93
9	·50	1·2247	4·90	6·12	7·35
10	·67	1·2910	5·16	6·45	7·75
11	·83	1·3540	5·42	6·77	8·12
12	2·	1·4142	5·66	7·07	8·49
13	·17	1·4720	5·89	7·36	8·83
14	·33	1·5275	6·11	7·64	9·17
15	·50	1·5811	6·32	7·91	9·49
16	·67	1·6330	6·53	8·16	9·80
17	·83	1·6833	6·73	8·42	10·10
18	3·	1·7321	6·93	8·66	10·39
19	·17	1·7795	7·12	8·90	10·68
20	·33	1·8257	7·30	9·13	10·95
21	·50	1·8708	7·48	9·35	11·22
22	·67	1·9149	7·66	9·57	11·49
23	·83	3·9579	7·83	9·79	11·75
24	4·	2·	8·	10·	12·
25	·17	2·0412	8·16	10·21	12·25
26	·33	2·0817	8·33	10·41	12·49
27	·50	2·1213	8·49	10·61	12·73
28	·67	2·1602	8·64	10·80	12·96
29	·83	2·1985	8·79	10·99	13·19
30	5·	2·2361	8·94	11·18	13·42
31	·17	2·2730	9·09	11·37	13·64
32	·33	2·3094	9·24	11·55	13·86
33	·50	2·3452	9·38	11·73	14·07
34	·67	2·3805	9·52	11·90	14·28
35	·83	2·4152	9·66	12·08	14·49
36	6·	2·4495	9·80	12·25	14·70
37	·17	2·4833	9·93	12·42	14·90
38	·33	2·5166	10·07	12·58	15·10
39	·50	2·5495	10·20	12·75	15·30
40	·67	2·5820	10·53	12·91	15·49
41	·83	2·6141	10·46	13·07	15·68
42	7·	2·6458	10·58	13·23	15·87
43	·17	2·6771	10·71	13·39	16·06
44	·33	2·7080	10·83	13·54	16·25
45	·50	2·7386	10·95	13·69	16·43
46	·67	2·7689	11·08	13·84	16·61
47	·83	2·7988	11·20	13·99	16·79
48	8·	2·8284	11·31	14·14	16·97
49	·17	2·8577	11·43	14·29	17·15
50	·33	2·8868	11·55	14·43	17·32
51	·50	2·9155	11·66	14·58	17·49
52	·67	2·9439	11·78	14·72	17·66
53	·83	2·9721	11·89	14·86	17·83
54	9·	3·	12·	15·	18·
55	·17	3·0277	12·11	15·14	18·17
56	·33	3·0551	12·22	15·28	18·33
57	·50	3·0822	12·33	15·41	18·49
58	·67	3·1091	12·44	15·55	18·65
59	·83	3·1358	12·54	15·68	18·81
60	10·	3·1623	12·65	15·81	18·97
61	·17	3·1885	12·75	15·94	19·13
62	·33	3·2145	12·86	16·07	19·29
63	·50	3·2404	12·96	16·20	19·44
64	·67	3·2659	13·06	16·33	19·60
65	·83	3·2914	13·17	16·46	19·75
66	11·	3·3166	13·27	16·58	19·90
67	·17	3·3417	13·37	16·71	20·05
68	·33	3·3665	13·47	16·83	20·20
69	·50	3·3912	13·56	16·96	20·35
70	·67	3·4157	13·66	17·08	20·49
71	·83	3·4400	13·76	17·20	20·64
72	12·	3·4641	13·86	17·32	20·78
73	·17	3·4881	13·95	17·44	20·93
74	·33	3·5119	14·05	17·56	21·07
75	·50	3·5355	14·14	17·68	21·21

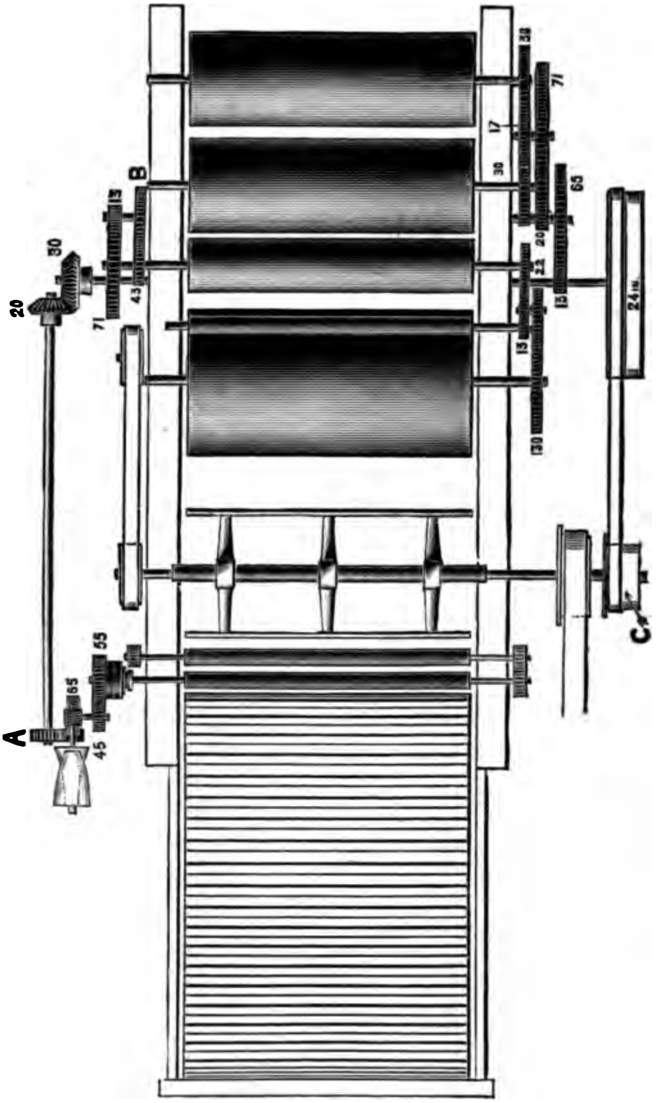
No. of yarn to be twstd	No. of twisted yarn.	Sq. root of No. twisted yarn	Square root multiplied by	
			5	6
76	12·67	3·5590	17·80	21·35
77	·83	3·5824	17·91	21·49
78	13·	3·6056	18·03	21·63
79	·17	3·6286	18·14	21·77
80	·33	3·6515	18·26	21·91
81	·50	3·6742	18·37	22·05
82	·67	3·6969	18·48	22·18
83	·83	3·7192	18·60	22·32
84	14·	3·7417	18·71	22·45
85	·17	3·7639	18·82	22·58
86	·33	3·7859	18·93	22·72
87	·50	3·8079	19·04	22·85
88	·67	3·8297	19·15	22·98
89	·83	3·8514	19·26	23·11
90	15·	3·8730	19·36	23·24
91	·17	3·8944	19·47	23·37
92	·33	3·9158	19·58	23·49
93	·50	3·9370	19·69	23·62
94	·67	3·9582	19·79	23·75
95	·83	3·9791	19·90	23·87
96	16·	4·	20·	24·
97	·17	4·0208	20·10	24·12
98	·33	4·0415	20·21	24·25
99	·50	4·0620	20·31	24·37
100	·67	4·0825	20·41	24·49
101	·83	4·1028	20·51	24·62
102	17·	4·1231	20·62	24·74
103	·17	4·1433	20·72	24·86
104	·33	4·1633	20·82	24·98
105	·50	4·1833	20·92	25·10
106	·67	4·2032	21·02	25·22
107	·83	4·2229	21·11	25·34
108	18·	4·2426	21·21	25·46
109	·17	4·2622	21·31	25·57
110	·33	4·2817	21·41	25·69
111	·50	4·3012	21·51	25·81
112	·67	4·3205	21·60	25·92
113	·83	4·3397	21·70	26·04
114	19·	4·3589	21·79	26·15
115	·17	4·3780	21·89	26·27
116	·33	4·3970	21·98	26·38
117	·50	4·4159	22·08	26·50
118	·67	4·4347	22·17	26·61
119	·83	4·4535	22·27	26·72
120	20·	4·4721	22·36	26·83
121	·17	4·4907	22·45	26·94
122	·33	4·5092	22·55	27·06
123	·50	4·5277	22·64	27·17
124	·67	4·5461	22·73	27·28
125	·83	4·5644	22·82	27·39
126	21·	4·5826	22·91	27·50
127	·17	4·6007	23·	27·60
128	·33	4·6188	23·09	27·71
129	·50	4·6368	23·18	27·82
130	·67	4·6547	23·27	27·93
131	·83	4·6726	23·36	28·04
132	22·	4·6904	23·45	28·14
133	·17	4·7081	23·54	28·25
134	·33	4·7258	23·63	28·35
135	·50	4·7434	23·72	28·46
136	·67	4·7610	23·80	28·57
137	·83	4·7784	23·89	28·67
138	23·	4·7958	23·98	28·77
139	·17	4·8132	24·07	28·88
140	·33	4·8305	24·15	28·98
141	·50	4·8477	24·24	29·09
142	·67	4·8648	24·32	29·19
143	·83	4·8819	24·41	29·29
144	24·	4·8990	24·49	29·39
145	·17	4·9160	24·58	29·50
146	·33	4·9329	24·66	29·60
147	·50	4·9497	24·75	29·70
148	·67	4·9666	24·83	29·80
149	·83	4·9833	24·92	29·90
150	25·	5·	25·	30·

APPENDIX.

THE following diagrams are given with a view of assisting, practically, overlookers and students in making their calculations for drafts and twists. In our diagram, the wheels that are usually changed in order to vary the proportions of movement are clearly shown by the figures and letters; and opposite each diagram is a skeleton specification of the machine itself. It is only necessary to carefully follow through the motions of the various machines in order to ascertain how clearly and thoroughly this can be done.

Every carding overlooker and every spinning overlooker ought to have in his office a complete set for the machines he overlooks, carefully filled up; and, by keeping a record in a business-like manner of any changes made, is not required to go to the machine to know what wheels are working.

It is hoped that this will prove of real practical advantage.


A
B
24in
C

SINGLE SCUTCHERS.

For.., ...189........

No. of Machines..................

One Beater 16 in., ...blades.

Width of Lap....................inches.

Down Draughts.

Revs. of Main Shaft per minute..............	Dia. of Drum on same..............	
,, Counter ,, ,, ...	Dia. of Pulley on same..............	Drum for Driving Beater...........
,, Beater ,, ,, ...	Dia. of Pulley on same..............	
,, ,, Fan ,, ...	Dia. of Pulley on same..............	
,, Lap Rollers ,, ...		

Feed Lattice..................feet per minute.

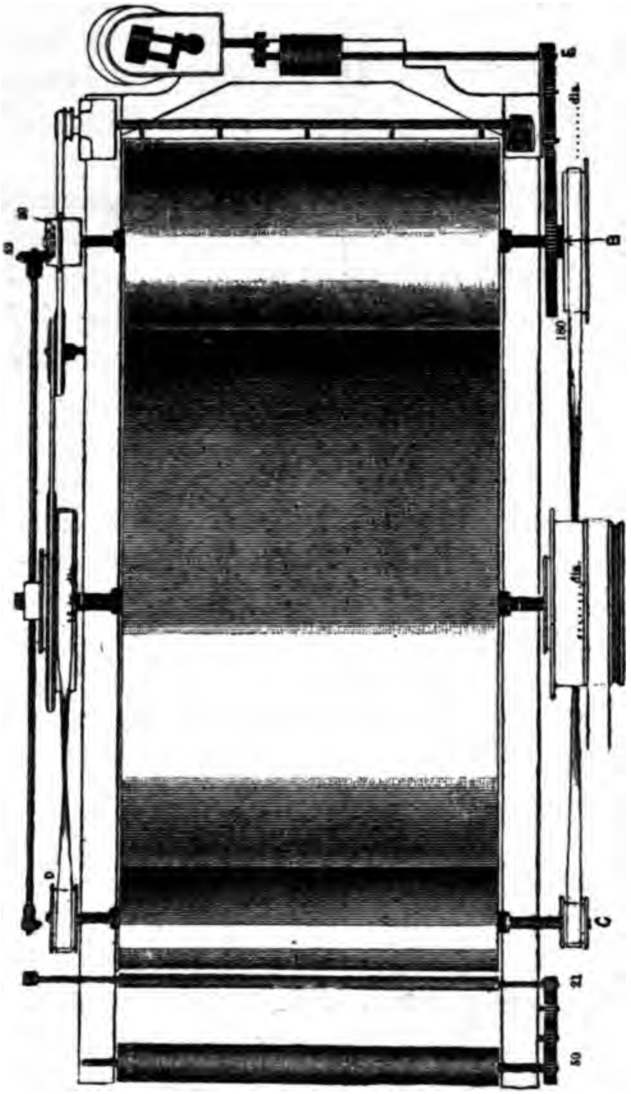
No. of Laps to be doubled...........

Total Draft............................

Kind of Cotton to be worked....................

CHANGE PLACES.

A—Draft.	Change Wheels, $\frac{24}{48}$ to $\frac{52}{20}$ (generally $\frac{48}{24}$).
B—Length of Lap.	One revolution of Calender Roller per Tooth of Change.
C—Time to make Lap.	Pulleys, 5 to $8\frac{1}{2}$ inches diameter.



E
dia.
B
180
dia.
C
21
50
D
19
20

"SIMPLEX" CARDING ENGINES.

For..., ...189...

No. of Cards.......................
Width of Lap.......... ....
Diameter of Main Cylinder... .... 50 in.
,, Doffer .... 24 in.
,, Taker-in .... 9¾ in. over teeth.
Number of Flats 110
One 2¼-in. Feed Roller with Dish.
One Lap Roller .... 6 in. dia.
Revs. of Main Shaft per minute...........................
Dia. of Drum on same... ....

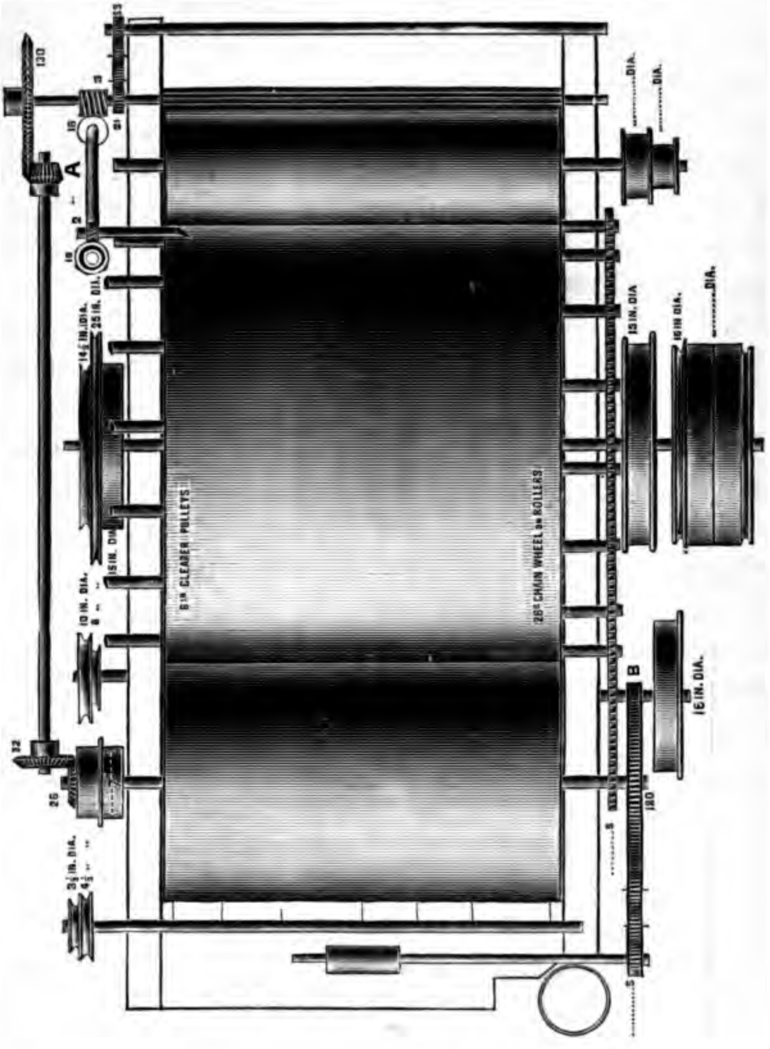
Dia. of Pulley on Card ....
Revs. of Cylinder per minute ....
Dia. of Grinding Roller................................. 6 in.
Kind of Cotton to be worked ....
Weight of Lap per yard.................
Sliver produced per yard ....
Calender Rollers .... 4 in. dia.
Strokes of Comb per minute............................
Length of Can.............. Dia. of ditto..............

CHANGE PLACES.

Change Wheels A	10	to	40 Teeth.
,, ,, B	16	,,	40 ,,
,, Pulleys C	8 in.	,,	5 in. dia.
,, ,, D	5 in.	,,	7½ in. ,,
,, Wheels E	24	,,	82 Teeth.

SENT ON CARDS.

A. (Side Shaft Wheel).
B (Barrow wheel).
C ....
D ....
E ....


130
15
15
21
A
2
19
14½ IN. DIA.
25 IN. DIA.
15 IN. DIA.
10 IN. DIA.
8 "
32
26
3½ IN. DIA.
4½ "
6th CLEARER PULLEYS
26th CHAIN WHEEL on ROLLERS
DIA.
DIA.
15 IN. DIA
16 IN. DIA.
DIA.
B
16 IN. DIA.
120
8
5

ROLLER AND CLEARER CARDING ENGINES.

For..., ...189........

No. of Cards..................... Width of Lap ....

Diameter of Main Cylinder.........................50 in.

„ Doffer ....24 in.

„ Taker-in ....9¾ in. over teeth.

„ Rollers ...., in No. of ditto..........................

„ Clearers ...., in „ „ ....

One 2¼ in. Feed Roller with Dish. One Lap Roller.................................... 6 in. diameter.

Revs. of Main Shaft per minute..................

Dia. of Drum on same ....

„ Pulley on Card ....

Revs. of Cylinder per minute....................

Dia. of Grinding Roller ....6 in.

Kind of Cotton to be worked................................

Weight of Lap per yard.........................

Sliver produced per yard ....

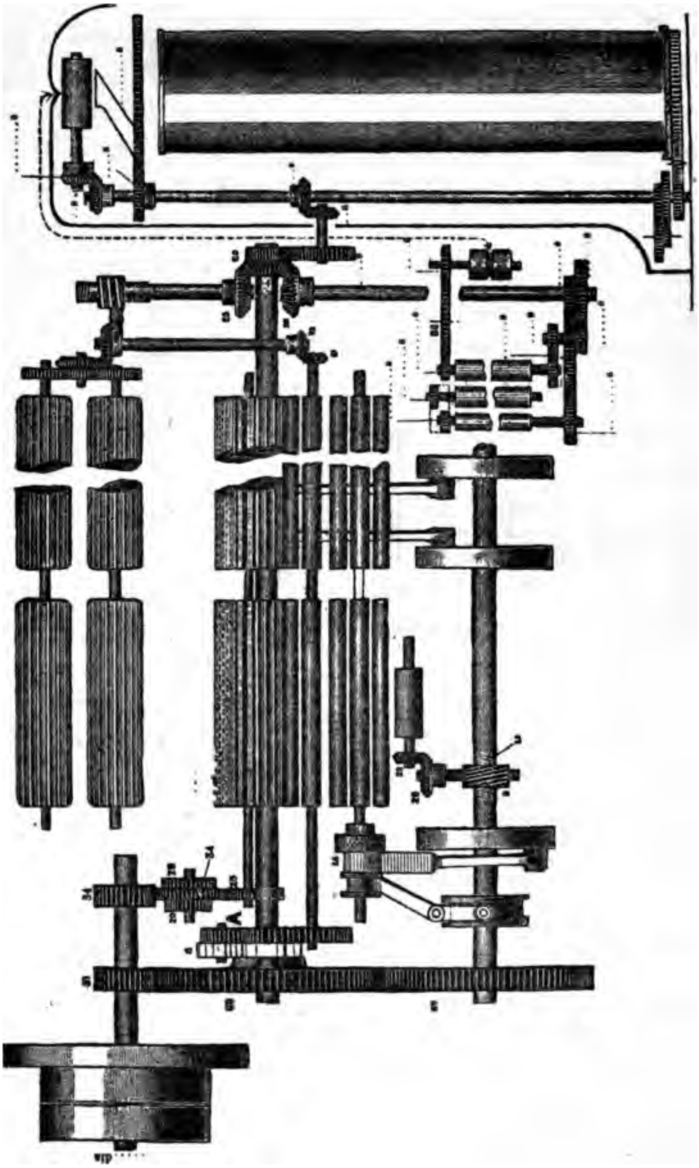
Calender Rollers or Draw-Box ....

Strokes of Comb per minute ....

Length of Can........................ Dia. of ditto.....................

CHANGE PLACES.

Change Wheels A .... 10 to 40 teeth | Change Wheels B .... 16 to 40 teeth.



COMBING MACHINES.

For.., ...189........

No. of Combers.. No. of Heads in each........... ....

Width of Lap.......................

Revs. of Main Shaft per minute .... Dia. of Drum on ditto ....

No. of Nips per minute..........................

Dia. of Draw-box Front Bottom Roller .... Ditto. Top Roller uncovered ....

„ „ Middle „ .... „ „ „ ....

„ „ Back „ .... „ „ „ ....

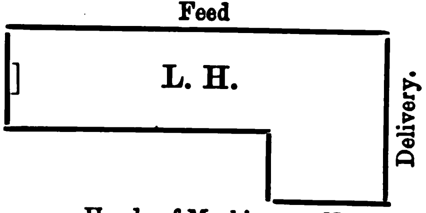
Total Draft in Draw-Box :—4 for six heads ; 5 for eight heads.

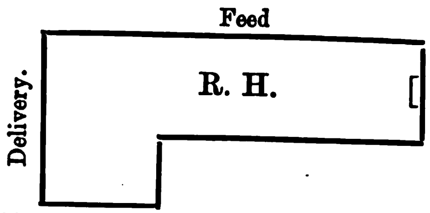
Length of Can................. Dia. of ditto.................. Dia. of Pulley on Machine.................

Kind of Cotton to be worked.—Egyptian and Sea Islands.

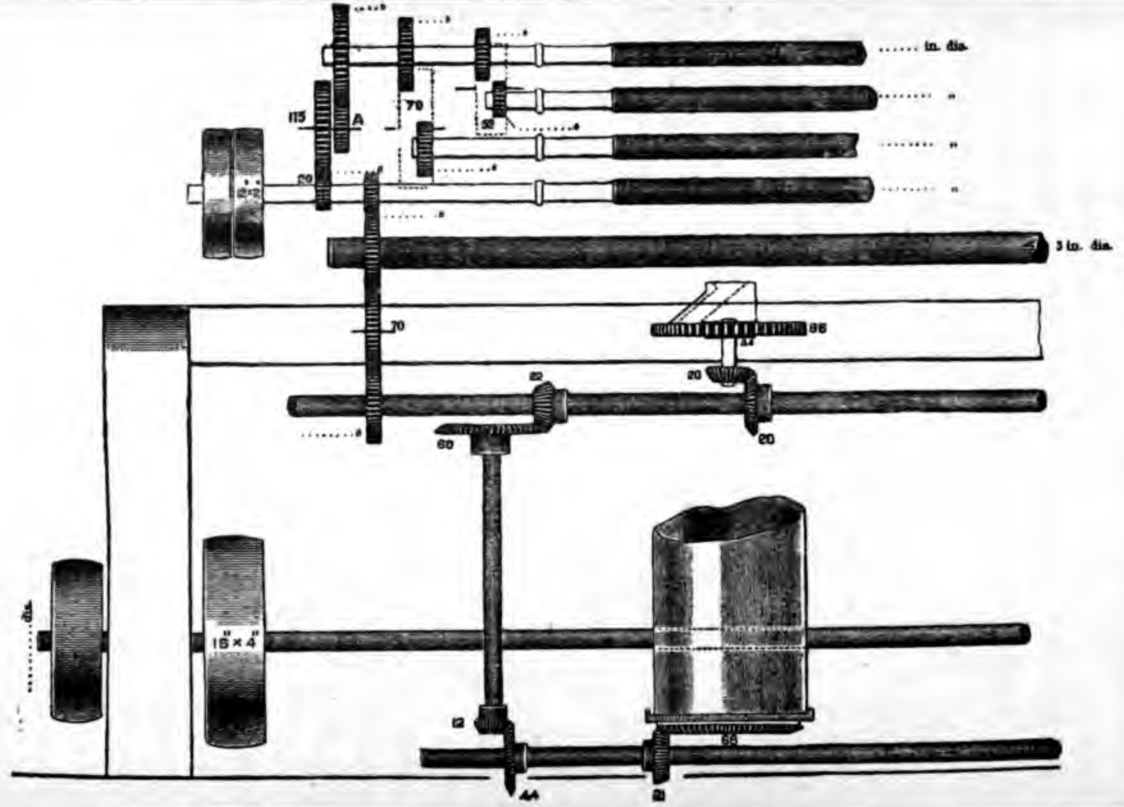
CHANGE PLACES.

A.—Feed .... Change Wheels 12 to 20 teeth.





Hands of Machines :—No. of L.H......................... No. of R.H.........................


in. dia.
"
"
"
3 in. dia.
A
15" × 4"
dia.

DRAWING FRAMES.

For.., ...189.........

No. of Frames............ No. of Heads in each.......... No. of Deliveries to each head.. ....

Four Lines of Rollers.

Diameter of Front Bottom Roller .. .. Ditto Top Roller uncovered ....

,, Second ,, ... ,, ,, ,, ...

,, Third ,, ... ,, ,, ,, ...

,, Fourth ,, ... ,, ,, ,, ...

Distance from centre to centre of Stands...................... ..

Slivers per Delivery........................

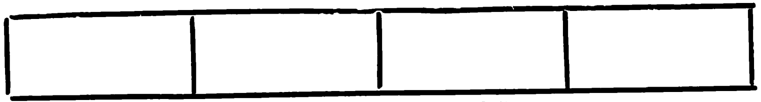
One Dead Weight for each Roller..........................pounds.

Revs. of Main Shaft per minute......................... Dia. of Drum on same........................

Dia. of Main Pulley on Frame........................ Revs. of Front Roller per minute..................

Dia. of Cans........................ .... Length of ditto.................................

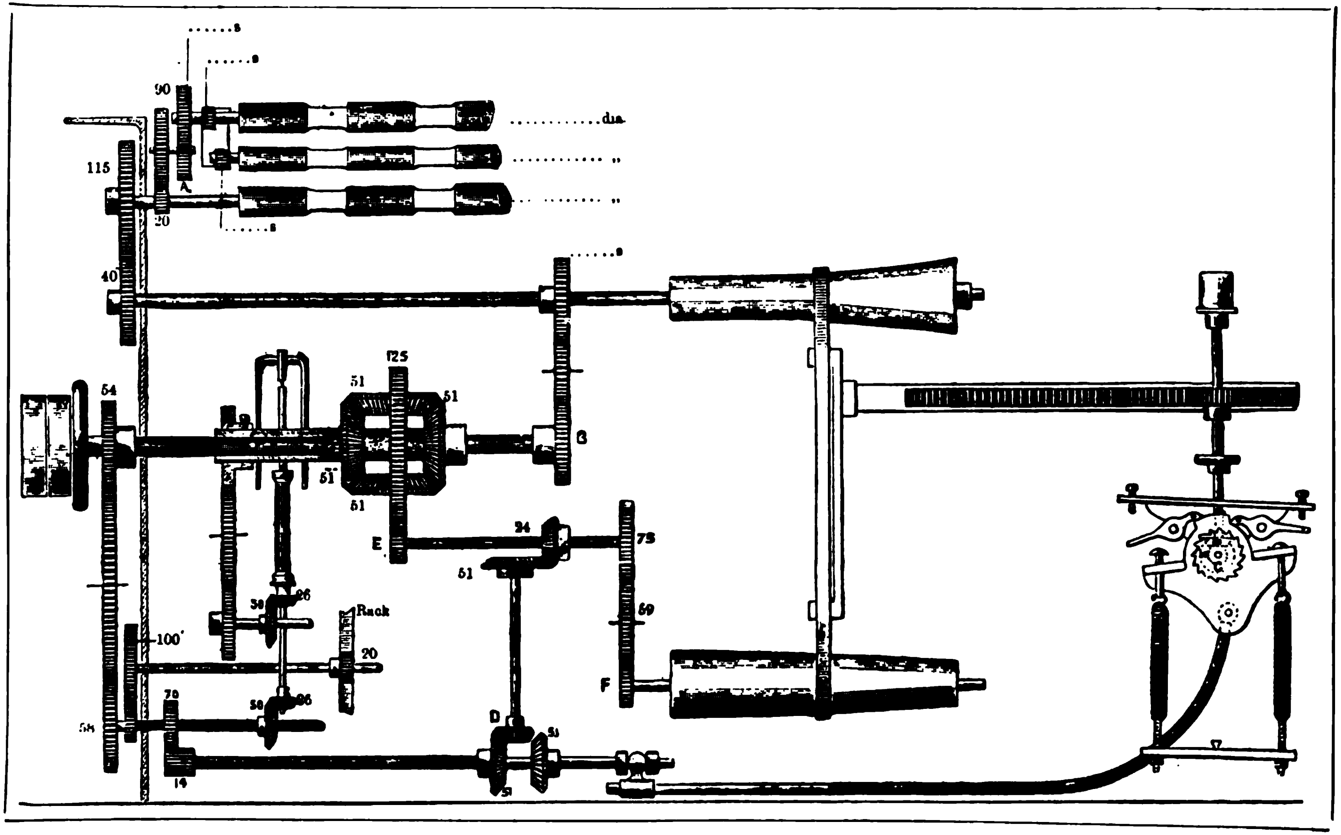
Kind of Cotton to be worked........................



Mark on this sketch position of Cans.

Change place A—40 to 90 teeth.

Back Roller and Draft Wheels for Draw Frames, Fly Frames, Mules, and Ring Frames are the same bore and pitch.


......8
......9
......dia.
......"
......"
A
......6
......9
G
E
Rack
F
D

SLUBBING FRAMES.

For.., ...189.....

No. of Frames...............

No. of Spindles.............. Dia. of ditto...... ....

Space of Spindles...........

Lift of Bobbin....... Dia. of the barrel of the Bobbin.......

Dia. of Bobbin when full..............

Bobbin to lead.

Spindles to run Weft way... or Twist way...

Collars—long............ short............

Three Lines of Rollers, one Thread per boss.

Dia. of Front Bottom Roller... Do. Top Roller uncovered...

,, Middle ,, ... ,, ,, ,, ...

,, Back ,, ... ,, ,, ,, ...

Lines of Weights......Weight of Weights......, ..., ...

Revs. of Main Shaft per minute..............

Dia. of Drum on same.................

Dia. of Pulley on Frame ....

Revs. of Spindles per minute..............

Revs. of Spindle for one of Driving Pulley on Frame...........

Kind of Cotton to be worked.................

CHANGE PLACES.

A—Draft ....Change Wheels—35 to 60.

B—Twist . ... ,, ,, 26 ,, 48.

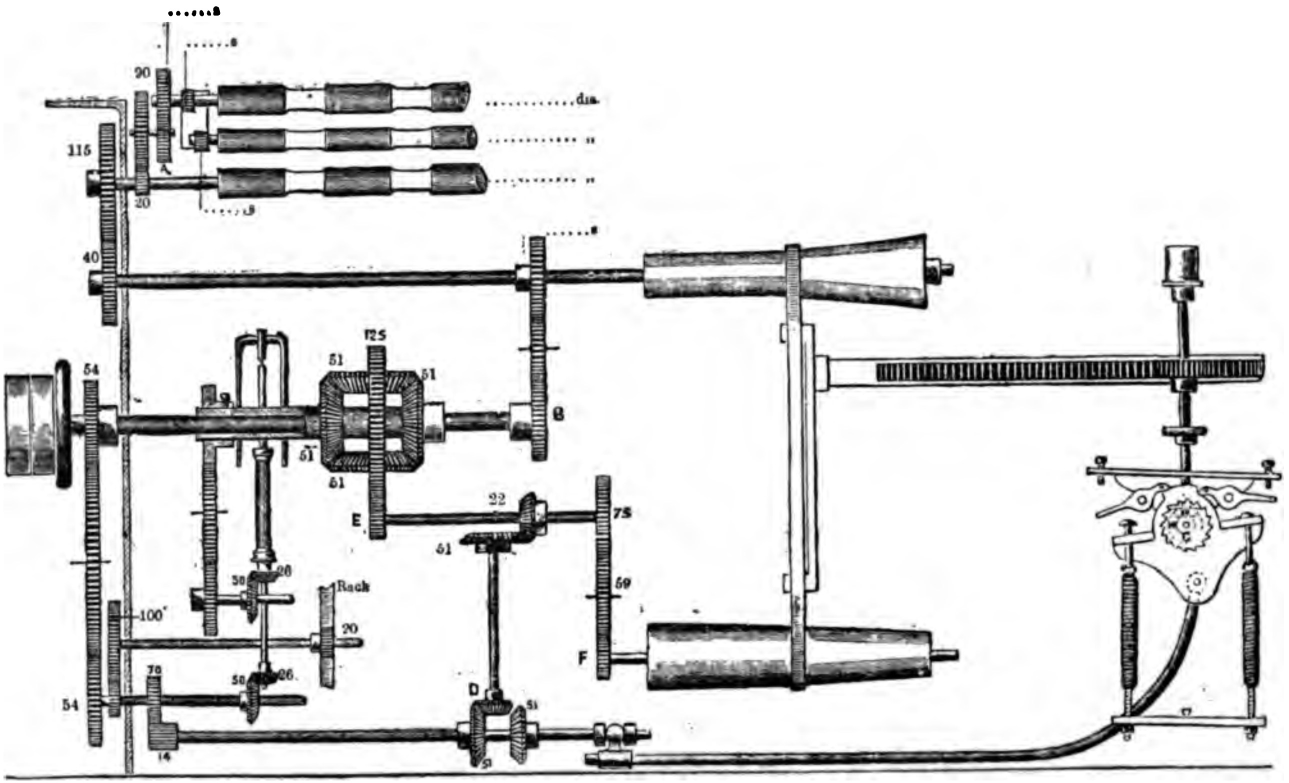
C—Winding (Star Wheel) ... .. ,, ,, 10 ,, 50.

D—Traverse (Lifter ,,) ...... ,, ,, 16 ,, 26.

E—Proportional to dia. of empty Bobbin (Jack Wh'l).15 ,, 30.

F—Traverse and dia. of Bobbin (Cone Wheel) ...14 ,, 30.

Back Roller and Draft Wheels for Draw Frames, Fly Frames, Mules, and Ring Frames are the same bore and pitch.



A
dia.
,,
,,
B
E
F
D
Rack
C

INTERMEDIATE FRAMES.

For.., ...189........

No. of Frames...............

No. of Spindles .... Dia. of ditto...........

Space of Spindles...............

Lift of Bobbin..... .. Dia. of the barrel of the Bobbin.......

Dia. of Bobbin when full..................

Bobbin to lead.

Spindles to run Weft way... or Twist way...

Collars—long......... short.........

Three Lines of Rollers, one Thread per boss.

Dia. of Front Bottom Roller.... Do. Top Roller uncovered...

,, Middle ,, ... ,, ,, ,, ...

,, Back ,, ... ,, ,, ,, ...

Lines of Weights...... Weight of Weights......, ... , ...

Revs. of Main Shaft per minute..................

Dia. of Drum on same..................

Dia. of Pulley on Frame...............

Revs. of Spindles per minute..............

Revs. of Spindle for one of Driving Pulley on Frame.............

Kind of Cotton to be worked.....................

CHANGE PLACES.

A—Draft.............................. Change Wheels—35 to 60

B—Twist .... ,, 26 ,, 48

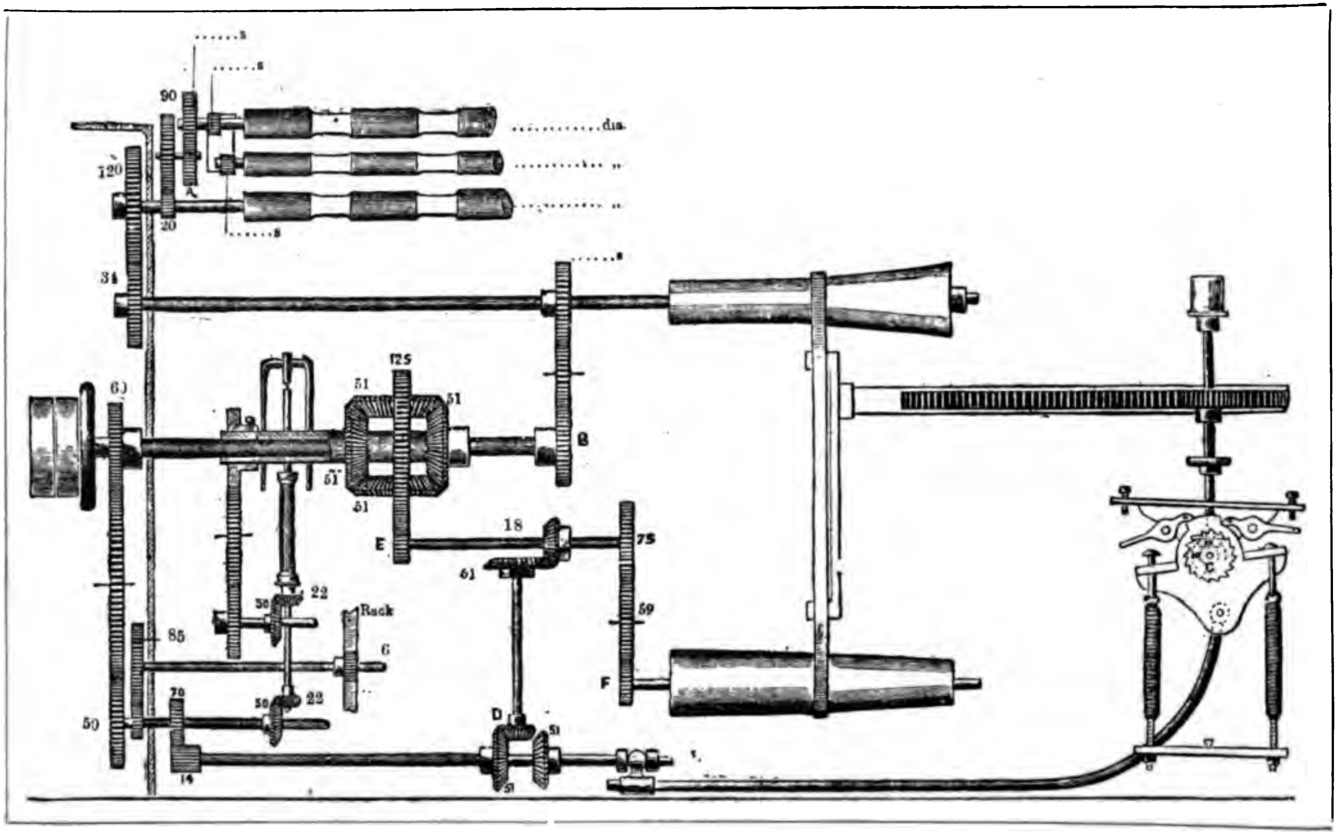
C—Winding (Star Wheel).......... ,, 10 ,, 50

D—Traverse (Lifter ,,).......... ,, 16 ,, 26

E—Proportional to dia. of empty Bobbin (Jack Wh'l). 15 ,, 30

F—Traverse and dia. of Bobbin (Cone Wheel) ...... 14 ,, 30

Back Roller and Draft Wheels for Draw Frames, Fly Frames, Mules, and Ring Frames are the same bore and pitch.



A
dia.
B
E
Rack
F
D

ROVING FRAMES.

For.., ...189........

No. of Frames......................

No. of Spindles .. .. Dia. of ditto...............

Space of Spindles...............

Lift of Bobbin........ Dia. of the barrel of the Bobbin........

Dia. of Bobbin when full..................

Bobbin to lead.

Spindles to run Weft way. .. or Twist way...

Collars—long............ short ....

Three Lines of Rollers,...... ......Threads per boss.

Dia. of Front Bottom Roller.... Do. Top Roller uncovered...

,, Middle ,, ... ,, ,, ,, ...

,, Back ,, ... ,, ,, ,, ...

Lines of Weights......Weight of Weights......, ..., ...

Revs. of Main Shaft per minute...... ....

Dia. of Drum on same............ .....

Dia. of Pulley on Frame............. .

Revs. of Spindles per minute ....

Revs. of Spindles for one of Driving Pulley on Frame...........

Kind of Cotton to be worked.................

CHANGE PLACES.

A—Draft.............................. Change Wheels—35 to 60

B—Twist................. .... ,, ,, 26 ,, 48

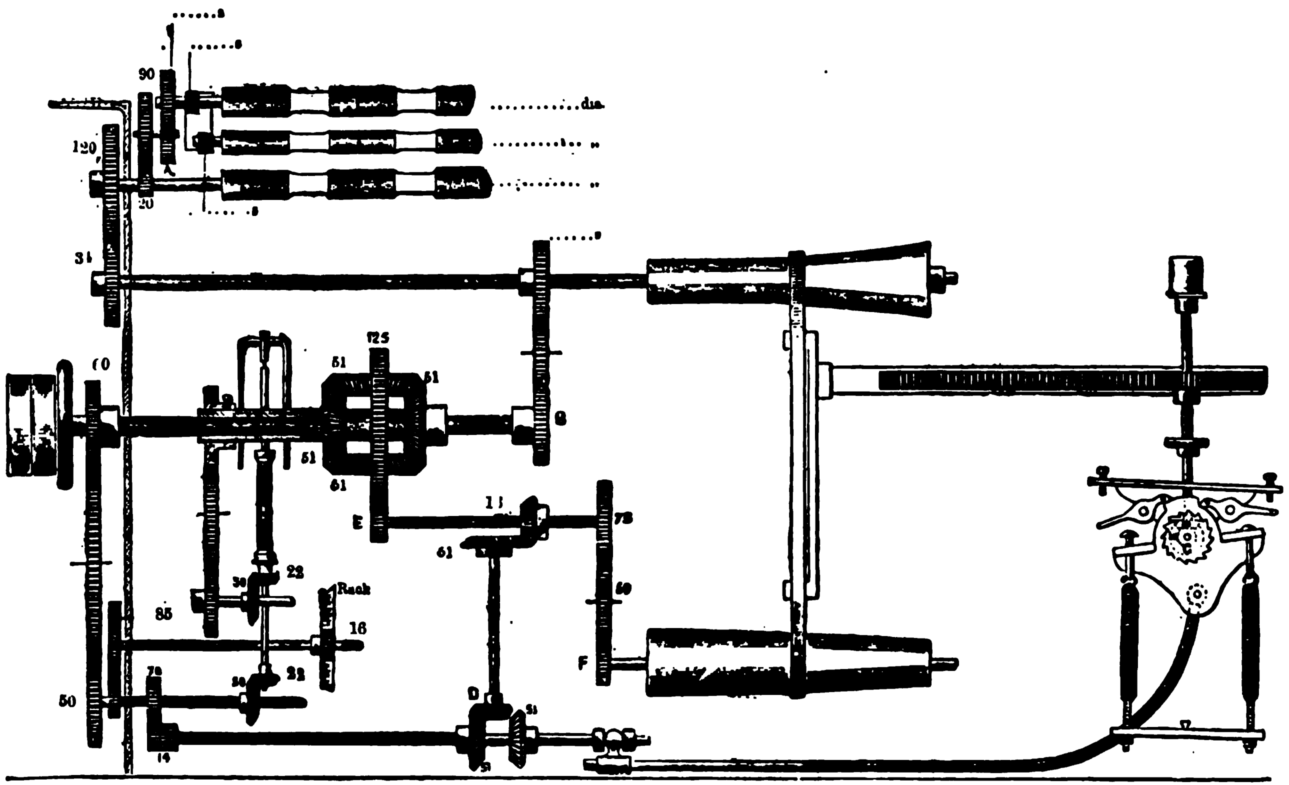
C—Winding (Star Wheel) .. .. ,, ,, 10 ,, 50

D—Traverse (Lifter ,,) .... ,, ,, 16 ,, 26

E—Proportional to dia. of empty Bobbin (Jack Wh'l).. 15 ,, 30

F—Traverse and dia. of Bobbin (Cone Wheel).........14 ,, 30

Back Roller and Draft Wheels for Draw Frames, Fly Frames, Mules, and Ring Frames are the same bore and pitch.


dia.
B
E
Rack
F
D

JACK FRAMES.

For.., ...189........

No. of Frames...............

No. of Spindles.... .... Dia. of ditto...............

Space of Spindles..........

Lift of Bobbin........ Dia. of the barrel of the Bobbin........

Dia. of Bobbin when full...... ....

Bobbin to lead.

Spindles to run Weft way.... or Twist way...

Collars—long........... short...........

Three Lines of Rollers,............Threads per boss.

Dia. of Front Bottom Roller... Do. Top Roller uncovered...

,, Middle ,, ... ,, ,, ,, ..

,, Back ,, ... ,, ,, ,, ...

Lines of Weights......Weight of Weights......, ..., ...

Revs. of Main Shaft per minute...............

Dia. of Drum on same...............

Dia. of Pulley on Frame...........

Revs. of Spindles per minute...........

Revs. of Spindles for one of Driving Pulley on Frame..........

Kind of Cotton to be worked....................

CHANGE PLACES.

A—Draft..... .... Change Wheels—35 to 60

B—Twist............................... ,, ,, 26 ,, 48

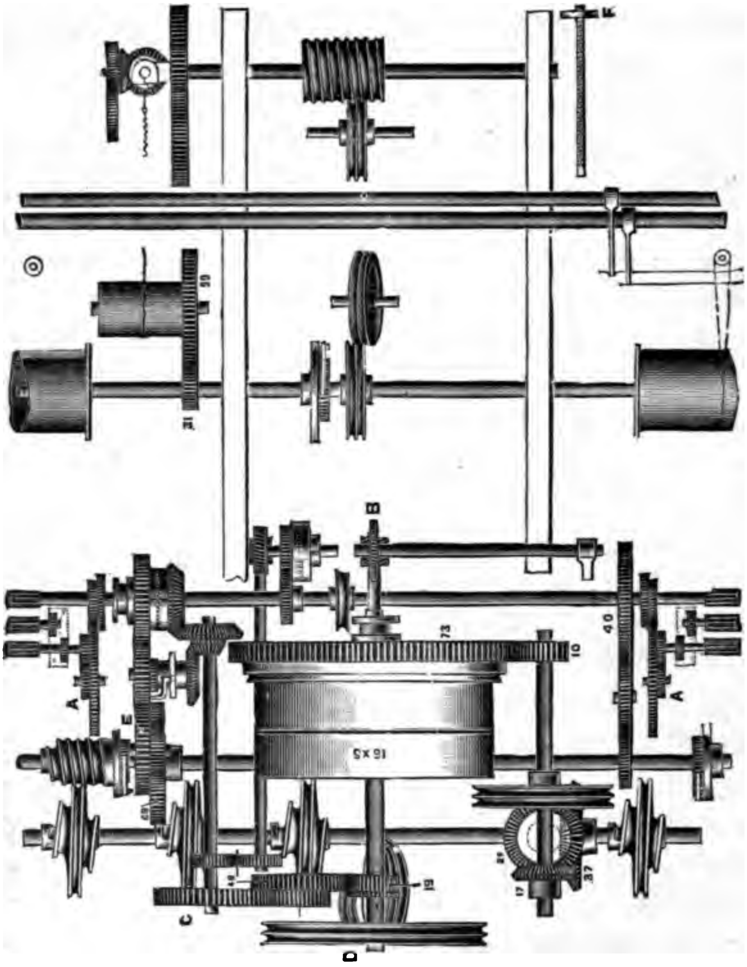
C—Winding (Star Wheel) .... ,, ,, 10 ,, 50

D—Traverse (Lifter ,,) .... ,, ,, 16 ,, 26

E—Proportional to dia. of empty Bobbin (Jack Wh'l). 15 ,, 30

F—Traverse and dia. of Bobbin (Cone Wheel) ...... 14 ,, 30

Back Roller and Draft Wheels for Draw Frames, Fly Frames, Mules, and Ring Frames are the same bore and pitch.


F
59
31
B
73
10
40
A
A
E
16×5
69
48
19
29
37
17
C
D

SELF-ACTING MULES.

For.., ...189.........

Number of Mules.................. Number of Spindles.................... Space of Spindles....................
Length of Spindle.................... Length of Spindle out of bolster ....
Dia. of Warve........................ Length of Draw.......................
Roller Motion........................
Double } Speed. Revs. of Line Shaft per minute...............................
Single }
Dia. of Drum on same—Double speed............................ Single speed..................................
Dia. of Pulley on Counter Shaft for—Double speed...................... Single speed.....................
Dia. of Drum on Counter Shaft.......................... Revs. of Rim Shaft per minute..........................
Three Lines of Bottom Rollers.
Dia. of Front Roller................. Ditto of Single, Double, Treble-boss Top Roller uncovered.................
„ Second „ .... „ „ „ „ „ ....
„ Third „ .... „ „ „ „ „ ....
Weights................................ Underclearers, Fluke Rods. Backing-off and drawing up by band.
Nosing Motion .... Governor Motion.........................
Kind of Cotton to be worked........................... Nos. to be spun.......................

SELF-ACTING MULES—Continued.

CHANGE PLACES.

A—Draft Wheel	Change Wheels	30 to 70 teeth.
B—Twist „	„ „	40 to 120 „
C—Back Change Wheel	„ „	60 to 110 „
D—Rim Pulley to change speed of spindles		9in. to 21in. dia.
E—Gain and Stretch	Gain Wheel.	70 to 78 teeth.
	Gain „ Pinion	16 to 20 „
F—Shaper Wheel		12 to 70 „

RULES FOR CALCULATING CHANGE WHEELS IN SELF-ACTING MULES.

TURNS OF SPINDLE FOR ONE OF RIM.

9in..............11in...............13in...............15in...............17in...............19in............... 21in.

TWIST WHEEL.

I = No. of inches of yarn put up per draw
T = Twist per inch
S = Turns of spindle for one of rim
Y = Twice the twist wheel (40 to 120)

$$\frac{I \times T}{S} = Y$$

BACK CHANGE WHEEL.

Y = Twice the twist wheel
19 = Rim spur
Z = No. of turns of front roller per draw
W = Back change (60 to 110)

$$\frac{Y \times 19}{Z} = W$$

REVS. OF FRONT ROLLER.

D = Dia. of front roller
G = Gain required
L = Length of Draw
R = Length of roving turned out by rollers
Z = No. of revs. of front roller per draw.

L—G = R

$$\frac{R}{D\ 3.1416} = Z$$

DRAFT WHEEL.

C = Top carrier wheel
B = Back roller „
F = Front roller „
DR = Draft required
V = Draft wheel (30 to 70)

$$\frac{C \times B}{F \times DR} = V$$

SELF-ACTING MULES—Continued.

GAIN AND STRETCH.

Z = No. of turns of front roller per draw ... .

55 = Front roller spur for fine numbers........................

51 = ,, ,, coarse ,, ...

70} = Gain wheel, which should be kept about 74's when
76} practicable.

68 = Back shaft wheel..... ....

*3-5 = Revs. of back shaft per draw 64in......................

†3-28 = ,, ,, ,, 60in............... ....

‡2-95 = ,, ,, ,, 54in.........................

X = Gain wheel pinion (16's to 20's—say 18's) ....

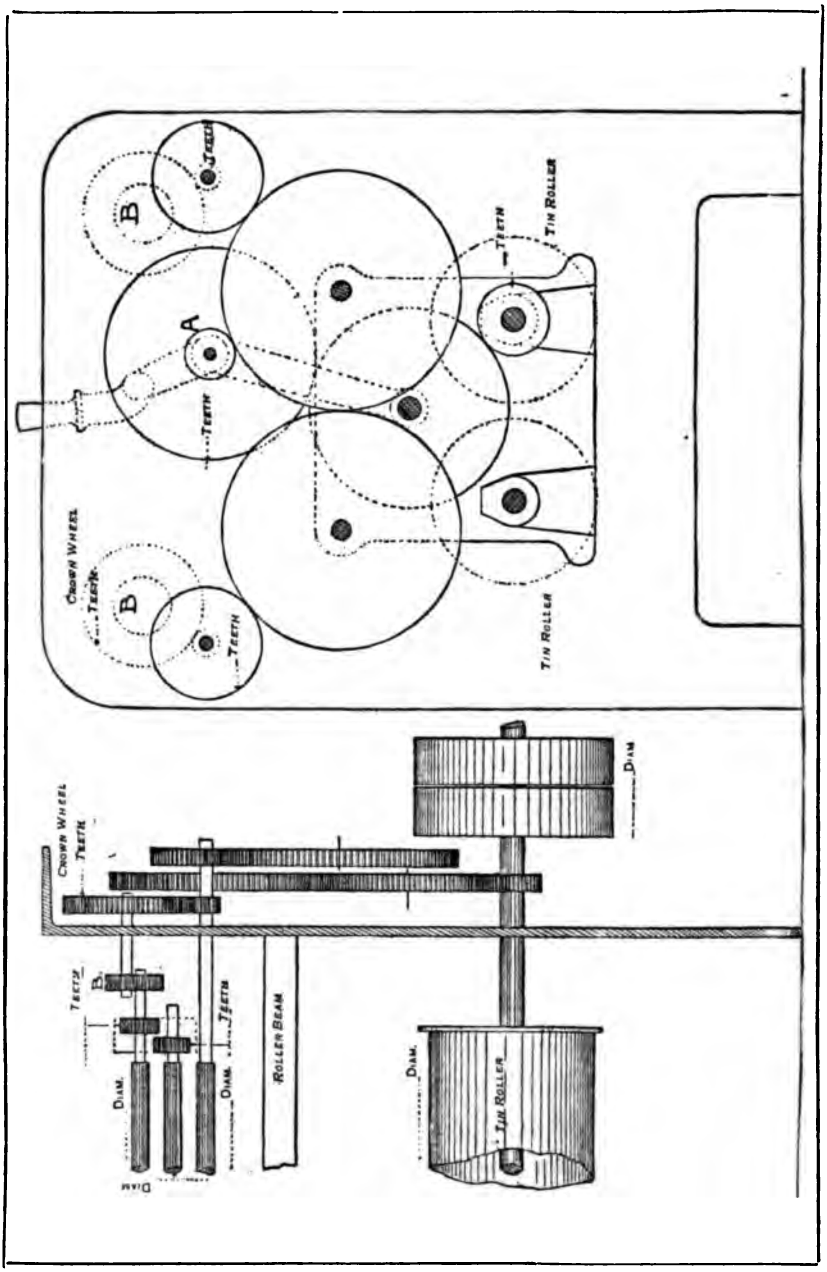
GW = Gain wheel from 70's to 78's—say 74's.................

$$\frac{68 \times 74 \times \left\{\begin{array}{c} 3\,.\,5 \\ \dagger 3\,.\,28 \\ \text{or} \\ \ddagger 2\,.\,95 \end{array}\right.}{Z \times 51 \text{ or } 55} = X$$

GAIN WHEEL.

$$\frac{Z \times 51 \text{ or } 55 \times X}{68 \times \left\{\begin{array}{c} {}^{*}3\,.\,5 \\ \dagger 3\,.\,28 \\ \text{or} \\ \ddagger 2\,.\,95 \end{array}\right.} = \text{G.W.}$$

Back Roller and Draft Wheels for Draw Frames, Fly Frames, Mules, and Ring Frames are the same bore and pitch.


B
Teeth
A
Teeth
Tin Roller
Teeth
Crown Wheel
Teeth
B
Teeth
Tin Roller
Diam
Crown Wheel
Teeth
Teeth
B.
Teeth
Diam.
Diam.
Diam
Roller Beam
Diam.
Tin Roller

RING SPINNING FRAMES.

For..., ...189........

No. of Frames.................. No. of Spindles in Frame.................. Space of Spindles.. ....

Length of Lift.................. Dia. of Spindle Warve.....................

Dia. of Ring .... Revs. of Spindles per minute ....

Spindles to run Weft way............ or Twist way...........

Revs. of Main Shaft per minute............... Dia. of Drum on ditto...............

Dia. of Pulley on Tin Roller.............. One or two Tin Rollers.............. Dia of ditto..............

Numbers of Yarn to be spun..........................

Twist per inch ....

Three Lines of Rollers ....

Diameter of Front Bottom Roller.................... Ditto Top Roller uncovered.....................

,, Middle ,, ... ,, ,, ,, ...

,, Back ,, ... ,, ,, ,, ...

The Rollers are weighted as follows:—...

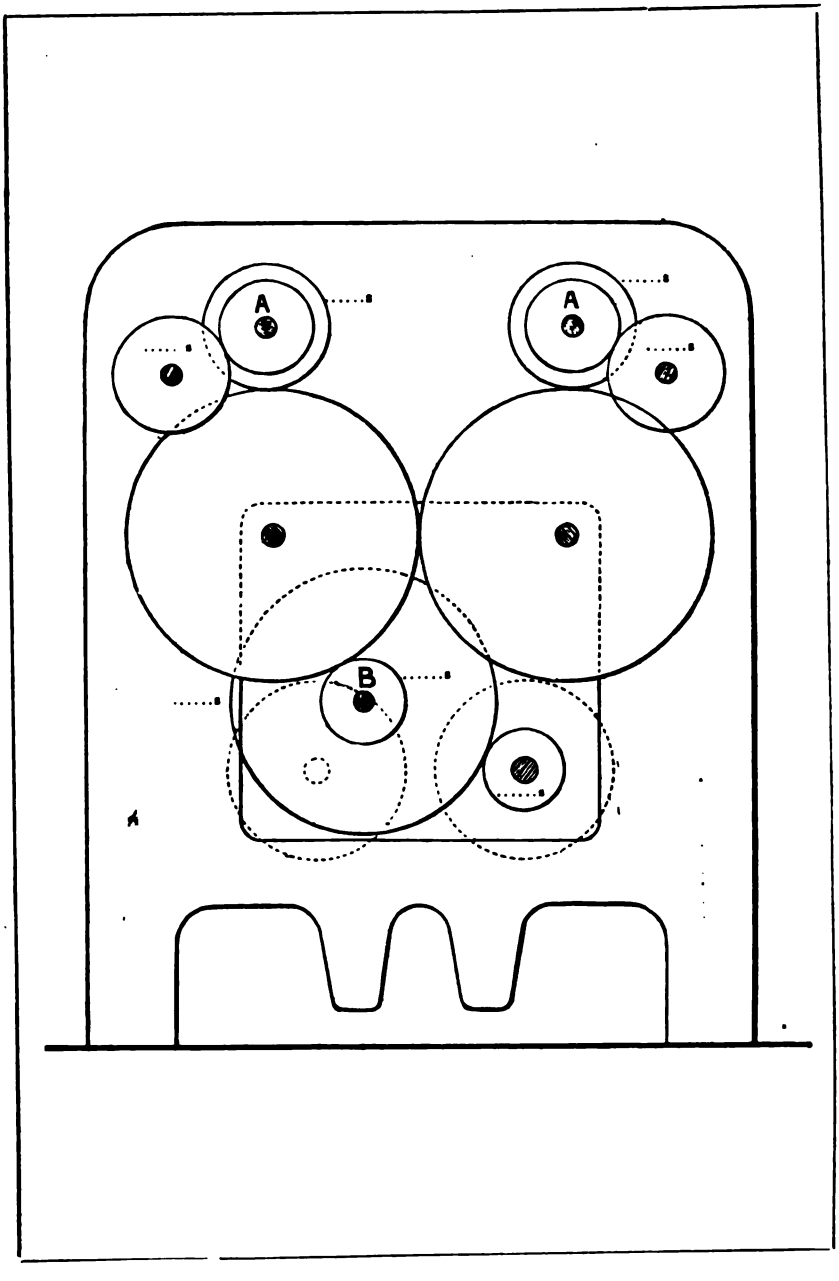
....

CHANGE PLACES.

A—Twist Wheel........................Change Wheels, 20 to 70 teeth.

B—Draft ,, ... ,, ,, 26 ,, 60 ,,

Back Roller and Draft Wheels for Draw Frames, Fly Frames, Mules, and Ring Frames are the same bore and pitch.


A
A
B

RING DOUBLING FRAMES.

For,……………………………………………………, ……………………189……

No. of Frames……………… No. of Spindles in Frame……………… Space of Spindles………………

Length of Lift……………… Dia. of Spindle Warve…………………

Dia. of Ring ……………… Revs. of Spindles per minute …………

Spindles to run Weft way…………… or Twist way…………

Revs. of Main Shaft per minute…………………

Dia. of Drum on ditto ……………………

Dia. of Pulley on Tin Roller ……………………

One or two Tin Rollers ………………………… Dia. of ditto……………

Numbers of Yarn to be doubled………………

Twist per inch ………………………………

Diameter of Bottom Roller……………………… Ditto Top Roller…………………

Wet or Dry Doubling…………………………

CHANGE PLACES.

A—Twist Wheel… …………………Change Wheels, 20 to 60 teeth.

B— „ „ …………………… „ „ 20 „ 80 „

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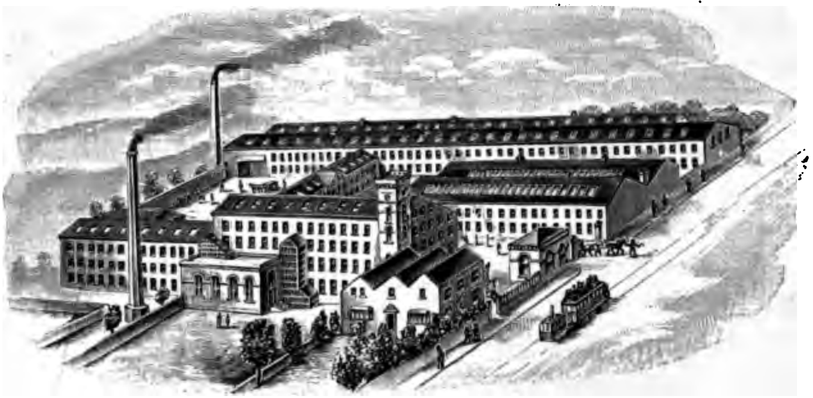

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PATENT PLOUGH-GROUND NEEDLE POINTS.
[See next page.]

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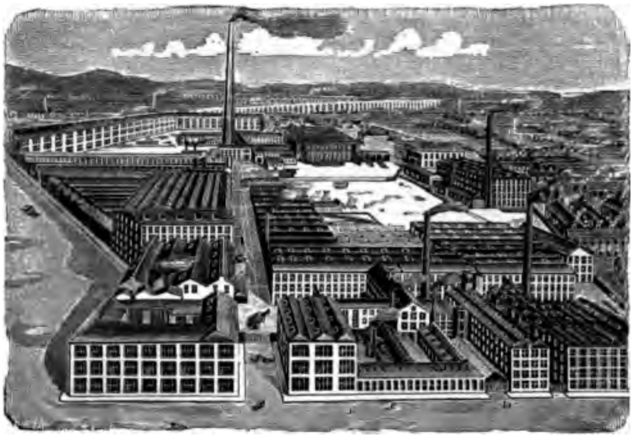


VIEW OF WORKS.

MAKERS OF

MACHINERY FOR PREPARING, SPINNING AND DOUBLING

Cotton, Cotton Waste, Wool, Worsted, Silk, & Vigonia Yarns.

Proprietors of Special Patents in the following Machines:

Double Cotton Gin with Double-Action Knife Roller, suitable for all classes of Cotton. Increased production.
Bale Breakers or Cotton Pullers.

VERTICAL OPENER.

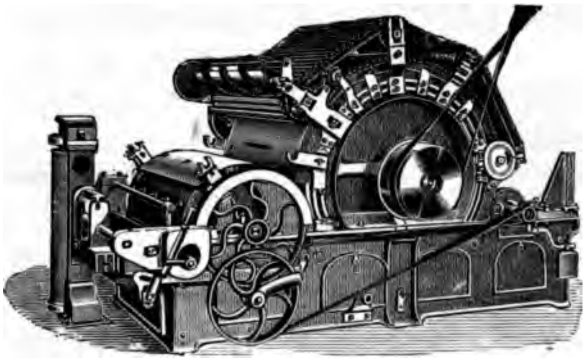
Vertical Conical Beater Openers, with or without Lap Machine.
Double and Single Openers, with or without Lap Machine.
Double and Single Scutchers, with or without pedal motion.

[See next page.]

Grinding Machines and **Grinding Rollers** on our improved principle.

Carding Engines on **Wellman's** principle, with our patented improvements.

Carding Engines with revolving flats with our improvements.



CARD.

Carding Engines, "Centenary Simplex," with revolving flats, with our Patent Automatic Flexible Bend Adjustment, 110 turn over flats, 44 constantly at work. Flats set to the cylinder to the two-thousandth part of an inch. Patent Adjustable Pedestal, mathematically correct, for adjusting cylinder in any direction.

Patent Anti-Deflection Grinding Motion, for grinding Flats from their working surface, wire downwards. Applicable to existing Cards.

Carding Engines, with rollers and clearers, specially adapted for waste and for coarse spinning, with or without Patent Condensers.

Sliver Lap Machines and **Derby Doublers.**

Heilmann's Cotton Combing Machines, of 6 or 8 heads, with our improvements for various kinds of Cotton.

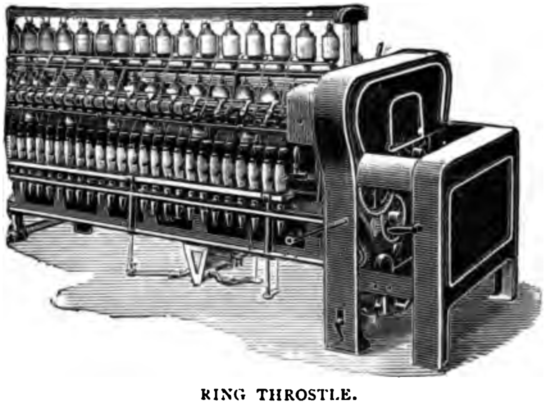
Patent "Duplex" Comber.

Patent Draw Frame and **Ribbon Lap Machine** combined, which gives increased out-turn, causes less waste and less wear to the Combers.

Drawing, Slubbing, Intermediate, Roving and **Jack Frames.**

Patent Self-acting Mules for spinning fine or coarse counts.

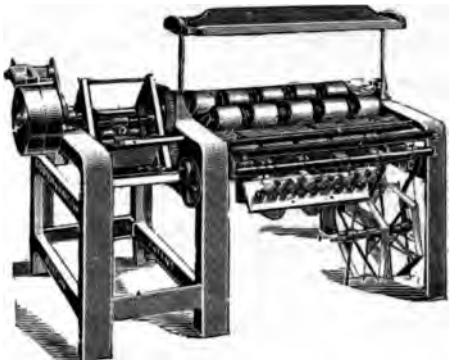
Patent Self-acting Mules for spinning Vigonia Yarns.



RING THROSTLE.

Ring Throstles and **Doublers** for Cotton, Silk, Combed Wool and Merino Yarns with our patented cork cushion flexible Spindle, also with the "Rabbeth" or other Spindle. **D. & B.'s Patent Automatic Anti-Ballooning Motion,** its application economising almost 10 per cent. spindle space; can be applied to existing Frames of any make.

Mule Twiners on our recently improved principle.



WINDING FRAME.

Patent Quick Traverse Drum Winding Frames, with or without Stop Motion to each end, for making parallel or conical bobbins, or parallel bobbins with tapered ends. Will make any length of bobbin up to 6in. on the same frame.

Improved Cop Winding Frame.

Patent Gassing Frames, with or without Patent Quick Traverse Motion, for winding on to wood or paper tubes, or with Patent Tapering Motion.

Patent Hank Winding and **Reeling Machine.**

Patent Automatic Bundling Press for hand or power.

Cop Reels on **Coleby's** principle, with our Patent Instantaneous Stop Motion for stopping the swift when a thread breaks, or when the required length is put on the swift.

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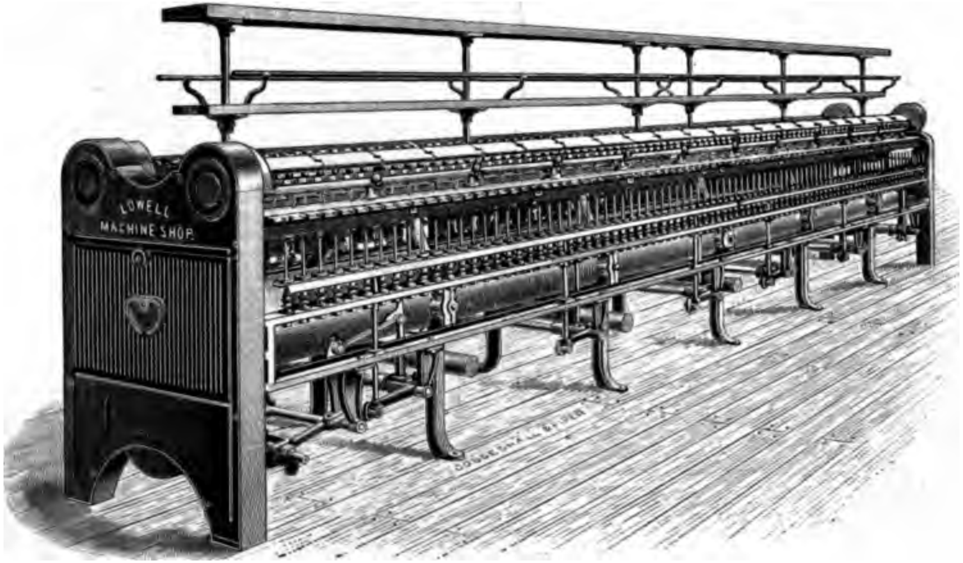
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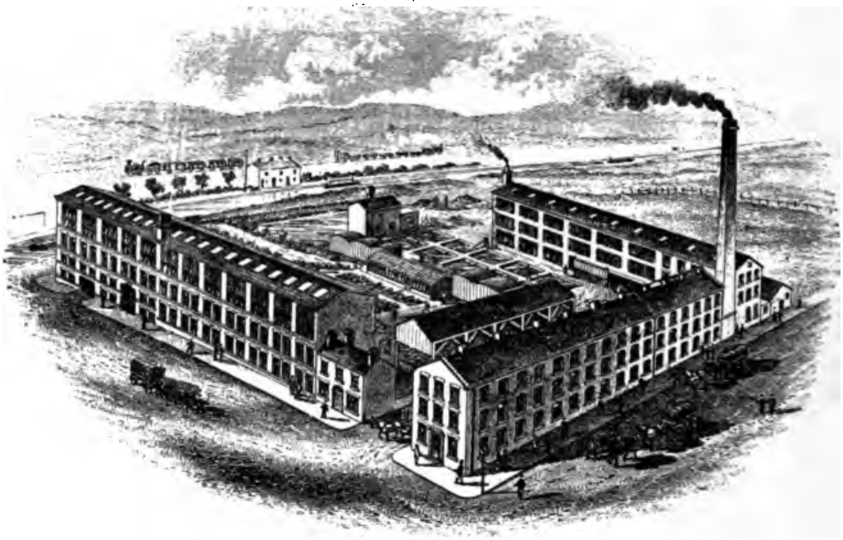

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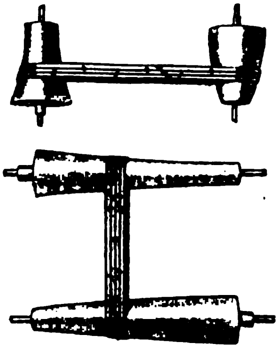

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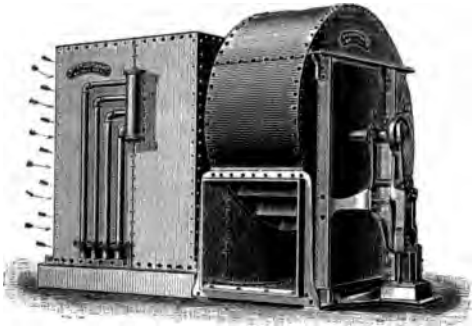

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